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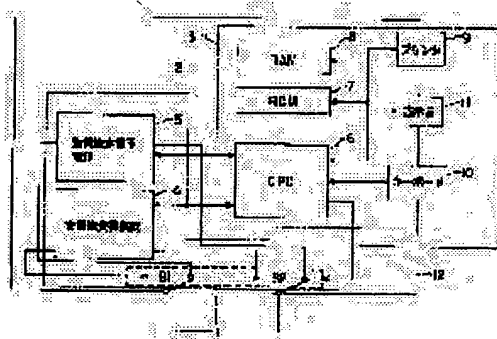
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(54) ALKALINE STORAGE BATTERY REMAINING CAPACITY ESTIMATION METHOD AND CAPACITY ESTIMATION DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To carry out the estimation of capacity in a short time in an arbitrary discharge state by estimating remaining capacity by applying an open circuit voltage, nominal capacity and estimated capacity in a pause state before and after charge or discharge to a voltage-capacity curve as well as estimating dischargeable capacity from full charge.

SOLUTION: A computer 3 measures, memorizes and records the terminal voltage and current of a test object cell or a combination battery 1, and additional data such as temperature, humidity and battery distortion as required at predetermined intervals while controlling a test in a condition set in advance. The computer applies a deterioration determining standard formula relative to a battery capacity and remaining capacity estimation method to the obtained test data, makes a deterioration determining formula from the deterioration determining standard formula according to a predetermined procedure to estimate the dischargeable capacity from fully charged state of the test object cell or the combination battery 1, and is provided with an arithmetic function to estimate the remaining capacity by applying it to a voltage-capacity relation formula, and furthermore, provided with a characteristic forming function to plot the test data at intervals of a certain period of time if necessary.



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CLAIMS

[Claim(s)]

[Claim 1] It is related with an alkaline battery (the following, a cell, and name) or the alkaline battery group (a following and group cell and name) connected to the serial. [two or more] Once setting a test objective cell or a group cell to hibernation, with a fixed current value, short-time-discharge or it charges. Ask for internal resistance from change of the terminal voltage before and behind that discharge or charge, and this internal resistance and the open-circuit voltage in hibernation. The degradation criterion type which consists of capacity, internal resistance, and open-circuit voltage is applied to the judgment type which carried out multiplier amendment with the internal resistance and nominal capacity of a new article cell of a test objective. The alkaline battery capacity residue presuming method characterized by presuming a residue on an electrical-potential-difference-capacity curve with the application of the open-circuit voltage and this nominal capacity in hibernation, and presumed capacity before and behind discharge or charge at the same time it presumes the discharge possible capacity from a full charge.

[Claim 2] This is once put on hibernation, carrying out the monitor of the terminal voltage of a cell or a group cell. Terminal voltage V_{oc1} After recording, short-time discharge or charge is performed with the fixed current value I . Terminal voltage V_2 immediately after the discharge and charge. Value $ZZ = \Delta V / I$ which recorded and *(ed) the electrical-potential-difference difference $\Delta V = V_{oc1} - V_2$ with discharge or a charging current value is calculated as internal resistance. Short-time discharge or charge is performed with the fixed current value I . Or the discharge, Terminal voltage V_{oc3} immediately after completing charge and starting a pause. Record and the electrical-potential-difference difference $\Delta V' = V_2 - V_{oc3}$ is discharged. Or it applies to carry out constant amendment of a degradation criterion type for which asked for value $Z'Z' = \Delta V' / I$ which *(ed) with the charging current value as internal resistance, and it asked from the cell property of a beforehand different degradation condition. At the same time it presumes the discharge possible capacity Q from the full charge condition of this test objective cell or a group cell. The terminal voltage V_{oc1} of the relaxation time before carrying out the above-mentioned short-time charge or discharge, Or terminal voltage V_{oc3} of the relaxation time immediately after operation. The residue (discharge remaining time) Q_{r0} and the above-mentioned short-time charge which were computed by having applied to the electrical-potential-difference-capacity curve of the new article cell of this test objective for which it asked beforehand, or nominal capacity Q_0 of the discharge possible capacity Q from the full charge condition presumed by discharge, this test objective cell, or a group cell from — residue (discharge remaining time) Q_r $Q_r = Q_{r0} (Q / Q_0)$

The alkaline battery capacity residue presuming method according to claim 1 characterized by presuming "Be alike."

[Claim 3] The formula by which the degradation criterion type used as the base of calculation is constituted from the logarithm and capacity Q of internal resistance Z in the approach of calculating the discharge possible capacity from the full charge condition of a test objective cell or a group cell $Q = a \ln(Z) + b$ (a and b are a constant and $a < 0$) (1) it is — capacity Q_A of the new article [constants / a and b / of this criteria type (1)] (non-deteriorated elegance) of a test objective cell or a group cell. Internal resistance Z_A of $Z_A = \Delta V / I$ using — $a \rightarrow a (Q_A / Q_B)$ $b \rightarrow Q_A - a(Q_A / Q_B) \ln(Z_A)$

(Capacity of the cell which used QB for criteria type creation)

The formula changed so that it might become, $Q = a(QA/QB) \ln(Z) + QA - a(QA/QB) \ln(ZA)$ (2) It uses as a degradation judging type. At this judgment ceremony (2) Internal resistance Z or the value Q which substituted and computed Z' — the discharge possible capacity from a full charge condition — carrying out — further — the open-circuit voltage Voc1 of a test objective cell or a group cell, or Voc3 The value of Q computed in the above-mentioned degradation judging type (2), and capacity QA of the corresponding non-deteriorated elegance Relation is $Voc1 < (Q/QA) 0.85x$ (the number of cells).

Or $Voc3 < (Q/QA) 0.85x$ (the number of cells)

The formula of capacity Q expressed with internal resistance Z and open-circuit voltage V instead of a degradation judging type (2), without using this Q value when becoming, $Q = QA \{ [\ln(Z) + dV - e] / (fV - g) \}$ (3) (d, e, f, and g are a constant) ***** — with the open-circuit voltage which constants d, e, f, and g were made to discharge to four steps of depth of discharge which is different about non-deteriorated elegance, and asked for them, and the value of internal resistance $Q = QA$ from — determining — this — using — this judgment type (3) — open-circuit voltage Voc1 or Voc3 The electrical-potential-difference-capacity curve used in order to make into the discharge possible capacity from a full charge condition the value Q which substituted and computed internal resistance Z or Z' and to presume a residue on the other hand Open circuit terminal voltage Vo of the new article cell set in the full charge condition of a test objective After recording, this Discharge by fixed time amount for 30 or less minutes by the current rate of 0.1C thru/or 0.2C, set this to the hibernation of 1 hours or more, and the open circuit terminal Vox is recorded on the last of relaxation time. It is made to discharge on the same conditions again, this is repeated to the electrical potential difference not more than 1.0V, and it is Vo. The alkaline battery capacity residue presuming method according to claim 2 characterized by being the curve which plotted and asked every charging time value (discharge capacity) for Vox.

[Claim 4] Record of the terminal voltage carried out in the alkaline battery capacity residue presuming method according to claim 2 in order to calculate the discharge possible capacity from the full charge condition of a test objective cell or a group cell, Charge or discharge conditions are the terminal voltage Voc1 before charge or discharge. Test objective cell, Or it is the electrical potential difference for less than 2 seconds which a group cell sets to hibernation and by which charge or discharge is started. Charge is carried out by the current rate of 0.05 or more C, and discharge is carried out by the current rate of 0.5 or more C. terminal voltage V2 which both charge and a charging time value is 1 or less second, and is recorded during charge or discharge Terminal voltage Voc3 which is an electrical potential difference in front of charge or discharge termination, and is recorded after charge or discharge termination The alkaline battery capacity residue presuming method characterized by being an electrical potential difference for less than 2 seconds after charge or discharge termination.

[Claim 5] the alkaline battery capacity presumption equipment characterize by to consist of a computer which manage data, and a charge and discharge machine which control the test condition of an alkaline battery, to build the circuit or the function of calculate the application criteria type and the electrical potential difference-capacity curve in the alkaline battery capacity residue presume method according to claim 2 in this computer, and to perform the capacity of a test objective cell or a group cell, and residue presumption according to the procedure of the alkaline battery capacity residue presume method according to claim 2.

[Claim 6] The computer which calculates in order to carry out collection management of the test data and to calculate capacity and residue estimate according to the alkaline battery capacity residue presuming method according to claim 2, [whether it consists of test discharge of this trial cell or a group cell, a current limiter which controls charge conditions, or a charge-and-discharge controller, and] Or the arithmetic circuit which performs the procedure of the alkaline battery capacity residue presuming method according to claim 2 to an established computer or alkaline battery capacity presumption equipment characterized by extending and coming to carry a function and consisting of this current limiter or a charge-and-discharge controller.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the alkaline battery capacity residue presuming method and capacity presumption equipment for predicting the capacity and the residue of the alkaline battery for backup in use.

[0002] In addition, capacity when capacity discharges until it resulted [from the full charge condition] in the assumption termination electrical potential difference, and a residue have pointed out the value of the capacity which shows how much [after] it can discharge to a convention termination electrical potential difference in the condition of having discharged to a certain range. Capacity is calculated by current x time amount, when it discharges with a fixed current.

[0003]

[Description of the Prior Art] In recent years, diversification of communication service and large-scale-ization advance, and high-reliability is also demanded of coincidence. In connection with this, installation of a variety of non-cut [the electric current] off electric supply systems or application of a backup power supply is promoted, and the rechargeable battery for backup has also come to be used in large quantities. Grasp of the residue display of the rechargeable battery for backup, maintenance, and a suitable replacement stage has been needed for dependability reservation of these equipments and a system.

[0004] There is a method of finding the time amount of constant-current discharge *Perilla frutescens* (L.) Britton var. *crispa* (Thunb.) Decne. until it reaches the discharge final voltage of terminal voltage's convention of a trial cell as the conventional rechargeable battery capacity presumption approach.

[0005] By this approach, the capacity of a cell had the fault that the electric supply to load equipment would become impossible if it becomes measurement of long duration and troubles, such as interruption of service, arise during measurement although it can ask correctly.

[0006] As an option, the internal impedance by the alternating current impedance is measured, or constant-current discharge of fixed time amount or charge is performed, it applies to the relation between the internal resistance which acquired the electrical-potential-difference response to this beforehand, using the value which **was** (ed) with the current value as internal resistance or an impedance, and cell capacity, and cell capacity is presumed.

[0007] Although capacity presumption was attained comparatively for a short time, the relation of the capacity of each size and each manufacturer cell and internal impedance which serve as a test objective beforehand needs to be grasped, this needed to be memorized, and huge data acquisition and storage capacity needed to be secured of this approach. It had the fault that furthermore it was necessary to carry out new data acquisition and record for every amelioration of a cell.

[0008] Furthermore, in order to improve the fault by these approaches, the high degradation criterion type of versatility applicable to the cell of varieties only by multiplier amendment was devised (Japanese Patent Application No. 7-238363). By this approach, while capacity presumption was attained comparatively simply by short-time discharge or charge, for the judgment, it had the fault that the full charge of the test objective cell always had to be carried out beforehand.

[0009] Moreover, only the capacity presuming method was proposed about these backup cells, and there was no residue presumption which is related with the cell for cycles which uses charge and discharge, repeating them frequently. Therefore, when the degradation condition of a backup cell was not grasped correctly, also producing the inconvenience of fulfilling the prospective time often existed.

[0010]

[Problem(s) to be Solved by the Invention] In order that the purpose of this invention may solve the above-mentioned present condition, it can carry out capacity presumption in the state of discharge of arbitration in a short time, and is to offer the alkaline battery capacity residue presuming method and capacity presumption equipment which can also presume a residue to coincidence.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention relates to an alkaline battery (the following, a cell, and name) or the alkaline battery group (a following and group cell and name) connected to the serial. [two or more] Once setting a test objective cell or a group cell to hibernation, with a fixed current value, short-time-discharge or it charges. Ask for internal resistance from change of the terminal voltage before and behind that discharge or charge, and this internal resistance and the open-circuit voltage in hibernation. The degradation criterion type which consists of capacity, internal resistance, and open-circuit voltage is applied to the judgment type which carried out multiplier amendment with the internal resistance and nominal capacity of a new article cell of a test objective. The alkaline battery capacity residue presuming method for presuming a residue on an electrical-potential-difference-capacity curve with the application of the open-circuit voltage and this nominal capacity in hibernation, and presumed capacity before and behind discharge or charge at the same time it presumes the discharge possible capacity from a full charge. It consists of a computer which manages data, and a charge-and-discharge machine which controls the test condition of a battery. The procedure of building the circuit or the function to calculate the degradation judging type and electrical-potential-difference-capacity relational expression in the capacity and the residue presuming method of this trial cell in this computer, and indicating it above is followed. A trial cell, Or the equipment characterized by performing capacity of a group cell, and residue presumption, It includes in an existing non-cut [the electric current] off electric supply system and an existing rechargeable battery charge-and-discharge automatic test equipment. With the computer which calculates in order to calculate capacity and residue estimate according to the cell capacity and the residue presuming method which carry out collection management of the test data for performing capacity of a trial cell, and residue presumption, and are indicated above, if required [whether it consists of a current limiter which controls the test condition of this trial cell, or a charge-and-discharge controller, and] Or if it extends and comes to carry the arithmetic circuit which performs the procedure of the cell capacity indicated above and the residue presuming method, or a function in an established computer and is required for it, the capacity and the residue presumption function which consist of this current limiter or a charge-and-discharge controller will be proposed.

[0012] The reason which can be presumed in precision with the high cell capacity and residue presuming method which become this invention By advance of cell degradation, although for example, negative-electrode cadmium changes with that the internal resistance of a cell increases by reduction of increase of reduction of the electrolytic solution in a separator, a positive electrode, and negative-electrode resistance, a negative electrode, and the matter, and advance of discharge to cadmium hydroxide and electrolytic-solution concentration changes. Since these degradation and depth of discharge are closely related to internal resistance, it thinks because the criteria type of the presuming method and electrical-potential-difference-capacity curve which consist of factors of terminal voltage, internal resistance, and capacity can be expressing the property of a cell to accuracy more.

[0013] In addition, depth of discharge makes 100% the case where it discharges until it resulted in the full discharge condition from a full charge condition to a convention termination electrical potential difference, and shows the magnitude (progress condition of discharge) of the amount of discharge. Depth of It is referred to also as DOD from Discharge. As description, it is the ratio (%) of discharge quantity of electricity to rated capacity. Conversely, there is especially no

language showing the progress condition of charge, and SOC (State of Charge) is often used.
[0014]

[Embodiment of the Invention] With reference to a drawing, the example of a gestalt of operation of this invention is explained to a detail below.

[0015] It is related with an alkaline battery (the following, a cel, and name) or the alkaline battery group (a following and group cell and name) connected to the serial. [two or more] This is once put on hibernation, carrying out the monitor of the terminal voltage of this cel or a group cell. Terminal voltage Voc1 After recording, short-time discharge or charge is performed with the fixed current value I. Terminal voltage V2 immediately after the discharge and charge Value $ZZ = \Delta V / I$ which recorded and $**(\text{ed})$ the electrical-potential-difference difference $\Delta V = V_{oc1} - V_2$ with discharge or a charging current value is calculated as internal resistance. Short-time discharge or charge is performed with the fixed current value I. Or the discharge, Terminal voltage Voc3 immediately after completing charge and starting a pause Record and the electrical-potential-difference difference $\Delta V' = V_2 - V_{oc3}$ is discharged. Or it applies to carry out constant amendment of a degradation criterion type for which asked for value $Z'Z' = \Delta V' / I$ which $**(\text{ed})$ with the charging current value as internal resistance, and it asked from the cel property of a beforehand different degradation condition. At the same time it presumes the discharge possible capacity Q from the full charge condition of this test objective cel or a group cell The terminal voltage Voc1 of the relaxation time before carrying out the above-mentioned short-time charge or discharge, Or terminal voltage Voc3 of the relaxation time immediately after operation The residue (discharge remaining time) Qr0 and the above-mentioned short-time charge which were computed by having applied to the electrical-potential-difference-capacity curve of the new article cel of this test objective for which it asked beforehand, or nominal capacity Qo of the discharge possible capacity Q from the full charge condition presumed by discharge, this test objective cel, or a group cell from — residue (discharge remaining time) $Q_r = Q_{r0} (Q / Q_o)$

It presumes "Be alike."

[0016] This invention is explained in more detail.

[0017] Degradation criterion type constituted from cell capacity Q and internal resistance Z in the cell capacity and the residue presuming method which become this invention by the approach of presuming the discharge possible capacity from a full charge condition $Q = a \ln(Z) + b$ (a and b are a constant and $a < 0$) (1) It uses as a fundamental relation type. It is based on the opposite numeric value of the internal resistance Z of a nickel-cadmium battery and the discharge possible capacity Q in a full charge condition having a straight-line relation about this criteria type (1) (N. Kato, et al., J.Power Source, (1997)). As a result of advancing examination further based on this result, on a cell by which the discharge possible capacity from a full charge exceeds 70% of nominal capacity and by which degradation is not advancing comparatively, it became clear for it to have been able to apply also to the cell in the depth of discharge of arbitration. Drawing 1 shows the basis.

[0018] Namely, drawing 1 is drawing having shown an example of the result which showed the magnitude of electrical-potential-difference response ΔV measured whenever it carried out fixed time amount discharge with the fixed current value. It is the curve which showed the magnitude of electrical-potential-difference response ΔV in each discharge condition of a non-deteriorated cell with 100% of capacity. 1-1 — a nominal capacity ratio — 1-2 — said — the curve of 90% of case — it is — 1-3 — said — the curve of 80% of case — it is — 1-4 — said — the curve of 70% of case — it is — 1-5 — said — it is the curve of 60% of case.

[0019] By the cell in which a nominal capacity ratio has 80% or more of capacity, magnitude ΔV of an electrical-potential-difference response is not based on a discharge condition, but it turns out that it is almost fixed so that clearly from drawing 1.

[0020] Therefore, as for the above-mentioned degradation criterion type (1) used in this invention, it turns out that it has completely different semantics from the relation of the internal resistance Z and capacity Q in connection with the cell of the conventional full charge condition, and application fields differ. That is, the internal resistance in the discharge condition of arbitration including a full charge condition can apply to the above-mentioned degradation criterion type (1).

[0021] The above-mentioned degradation criterion type (1) is the nominal capacity QA of a test

objective cell or a group cell about multipliers a and b. Internal resistance Z. It is changed. $Q = a(QA/QB) \ln(Z) + QA - a(QA/QB) \ln(ZA)$ (2) (capacity of the cell which used QB for criteria type creation) It is used for presumption of the discharge possible capacity from a full charge condition as a becoming degradation judging type.

[0022] In addition, derivation of the above-mentioned degradation judging type (2) was performed by being as follows.

[0023] It is QB about the capacity of the cell B used for creating the above-mentioned degradation criterion type (1). Supposing the capacity of the cell which was used for carrying out and similarly creating this formula (1) and which deteriorated sharply is $1/[$ of the capacity of Cell A $]$ n and internal resistance is p times the cell A $QB = a \ln(ZB) + b$ (21) $QB/n = a \ln(ZB) + [a \ln(p) + b]$ (22) It is realized.

[0024] Here, they are the capacity Q of a test objective cell, and the relation of internal resistance Z. $Q = a * \ln(Z) + b$ (a^* and b^* are a constant and $a^* < 0$) (23) Suppose that it is realized.

[0025] the capacity of the test objective cell A which constitutes a formula (13) — QA and internal resistance Z — the internal resistance of the cell used for carrying out and similarly creating this formula (1) is p times the cell A — supposing it is a degradation cell sharply and the capacity is $1/[$ of the capacity Of Cell A $]$ m $QA = a * \ln(ZA) + b$ (24) $QA / m = a * \ln(ZA) + [a * \ln(p) + b]$ (25) It becomes.

[0026]

From a formula (11)—type (12) $QB [1 - (1/n)] = -a \ln(p)$ (26) From a formula (14)—type (15) $QA = [1 - (1/m)] = -a * \ln(p)$ (27) Formula (16) / formula (17) $(QB/QA) [(1 - 1/n) / (1 - 1/m) = a/a^*]$ (28) $n \gg 1$ Since it is 1 and $m \gg 1$, it is from a formula (18). $a^* = a(QA/QB)$ (29) A formula (19) is substituted for a formula (14). $b^* = QA - a(QA/QB) \ln(ZA)$ (30) A formula (19) and a formula (20) can be substituted for a formula (13), and the above-mentioned degradation judging type (2) can be obtained.

[0027] Only when advance of a degradation condition progresses and it is in a full charge condition, it becomes impossible however, to apply the above-mentioned degradation judging type (2). It is clear by drawing 1 shown previously.

[0028] namely, the nominal capacity ratio to which degradation advanced in drawing 1 — by the cell of 70% and 60% of capacity, magnitude ΔV of an electrical-potential-difference response becomes large as discharge progresses. When open-circuit voltage V_{oc} becomes less than $[1.20V]$ especially, increase of ΔV is remarkable and a degradation judging type (2) is unapplicable ability in as $[this]$ at the trial cell or group cell of the condition that depth of discharge is deep.

[0029] then, formula of capacity Q expressed with internal resistance Z and open-circuit voltage V as a degradation judging type replaced with the above-mentioned judgment type (2) $Q = QA \{[\ln(Z) + dV - e] / (fV - g)\}$ (3) (d, e, f, and g are a constant) It proposes in this invention.

[0030] The above-mentioned degradation judging type (3) is the relational expression created on the basis of the result of magnitude ΔV of the electrical-potential-difference response with each depth of discharge $[as / in \text{drawing 1}]$. the open-circuit voltage for which the constants d, e, f, and g in this judgment type (3) were made to discharge to four steps of different depth of discharge about the non-deteriorated elegance applicable to a test objective cell or a group cell, and it asked, the value of internal resistance, and capacity QA calculated from nominal capacity from — $Q = QA$ — it applies to (3) types, and these are determined and used.

[0031] The derivation procedure of the above-mentioned degradation judging type (3) is outlined below.

[0032] The logarithm of electrical-potential-difference response ΔV and relation with open-circuit voltage V are shown in drawing 2. Between the opposite numeric value of electrical-potential-difference response ΔV , and open-circuit voltage V, very good straight-line relation is obtained so that clearly $[drawing 2]$.

[0033] drawing 2 — setting — 2-1 — a nominal capacity ratio — the straight line which showed the open-circuit voltage V of a non-deteriorated cell and the relation of electrical-potential-difference response ΔV with 100% of capacity — it is — 2-2 — said — the straight line of 90% of case — it is — 2-3 — said — the straight line of 80% of case — it is — 2-4 — said — the straight line of 70% of case — it is — 2-5 — said — it is the straight line of 60% of case.

[0034] Therefore, the following relational expression is materialized between internal resistance Z and open-circuit voltage V .

[0035]

$\ln(Z) = -jV + k$ (31) $\ln(31)$ it depends for multipliers j and k on [cell's degradation], i.e., Q/QA , (QA is nominal capacity) linearly. $j = -f(Q/QA) + d$ (32) It reaches. $k = -g(Q/QA) + e$ (33) It becomes. If (32) and (33) are substituted for (31) $\ln(Z) = -[-f(Q/QA) + d]V + [-g(Q/QA) + e]$ (34) $\ln(Z) = (fV - g)(Q/QA) - dV + e$ (35) The above-mentioned degradation judging type (3) can be found from (35) types.

[0036] To this judgment type (3), open-circuit voltage V_{oc1} and $**$ are V_{oc3} . Let the value Q which substituted and computed internal resistance Z or Z' be the discharge possible capacity from a full charge condition.

[0037] The conditions which apply a degradation judging type (3) instead of a formula (2) are the open-circuit voltage V_{oc1} of a test objective cel or a group cell, or V_{oc3} . The discharge possible capacity Q from the full charge condition presumed using the degradation judging type (2), and capacity QA of the corresponding non-deteriorated elegance Relation judges from experimental data and it is $V_{oc1} < (Q/QA)0.85x$ (the number of cels).

Or $V_{oc3} < (Q/QA)0.85x$ (the number of cels)

It is the case where it becomes. If a degradation judging type (3) is used when the above-mentioned ratio is more than $0.85x$ (the number of cels), it becomes [the error of estimate] large and is not more desirable than a degradation judging type (2).

[0038] By the approach of becoming this invention, while becoming possible to do in this way and to calculate the discharge possible capacity Q from a full charge condition, the residue how much [after] it can discharge from the discharge condition at the time of a trial to coincidence can also be judged.

[0039] Namely, the terminal voltage V_{oc1} of the relaxation time before carrying out the above-mentioned short-time charge or discharge, Or terminal voltage V_{oc3} of the relaxation time immediately after operation The residue (discharge remaining time) Q_{r0} and the above-mentioned short-time charge which were computed by having applied to the electrical-potential-difference-capacity curve of the new article cel of this test objective for which it asked beforehand, or capacity QA of the non-deteriorated elegance of the discharge possible capacity Q from the full charge condition presumed by discharge, this test objective cel, or a group cell from — residue (discharge remaining time) Q_r $Q_r = Q_{r0} (Q/QA)$

The electrical-potential-difference-capacity curve used in order to presume the residue it is presumed be alike Open circuit terminal voltage V_o of the new article cel set in the full charge condition of a test objective After recording, this Discharge by fixed time amount for 30 or less minutes by the current rate of $0.1C$ thru/or $0.2C$, set this to the hibernation of 1 hours or more, and the open circuit terminal voltage V_{ox} is recorded on the last of relaxation time. It is made to discharge on the same conditions again, this is repeated to the electrical potential difference not more than $1.0V$, and it is V_o . Every charging time value (discharge capacity) is plotted and asked for V_{ox} .

[0040] In addition, C is one value which shows the magnitude of the current value of discharge or charge. There is a view of the rate of time amount, and, in this case, a current value is expressed with a way of speaking called the rate discharge of t time amount to discharging until it becomes a termination electrical potential difference with Current I for t hours. The rated capacity (nominal capacity) of a cell is then used as C . For example, when calling it $1C$, the rate discharge of 1 time amount which ends discharge in 1 hour is shown. When rated capacity is the cell of $1Ah$, it means discharging with the current value of $1 \times 2 = 2A$. 0. If it is called $2C$, it will discharge with the current value of $0.2 \times 2 = 0.4A$, and this will become the rate discharge of 5 time amount (discharge takes 5 hours). The value of nominal capacity is applied to C , and a current value can be found if it multiplies by the numeric value before that.

[0041] Although the discharge conditions for asking for the above-mentioned electrical-potential-difference-capacity curve will not be limited to this if they are 0.2 or less C 0.1 or more C , its calculation tops $0.1C$ and $0.2C$ are simple, and they are desirable. [of the tops] 0 . The condition of a cell may change with elements other than discharge (especially self-discharge) during a trial by discharge of less than $1 C$ taking huge time amount, in order to ask for this curve, and it is not desirable. Moreover, it becomes [the hibernation after discharge is

unstable and / the error of an electrical potential difference] large in the big current rate exceeding 0.2C, and is not desirable.

[0042] If a charging time value is furthermore made longer than 30 minutes, it will lead to reduction of the number of data, the fall of the dependability of an electrical-potential-difference-capacity curve it is unreliable on criteria will be caused, and it is not desirable. It becomes [about the quiescent time, if it is less than 1 hour, will not result in stable hibernation, but / the error of an electrical potential difference] large and is not desirable.

[0043] By the cell capacity and the residue presuming method which become this invention, once setting to hibernation the alkaline battery (cel) used as a test objective, or two or more group cells which were connected to the serial, short-time discharge is carried out with a fixed current value, and change of the terminal voltage is measured.

[0044] As for charge required for presumption, and a charging time value, it is desirable that it is 1 or less second. Since the effect by the delay of diffusion of not only the internal resistance of a cell but the ion in the electrolytic solution comes to be strongly included in change of terminal voltage and this effect enlarges a judgment error in charge or the long time amount by which a charging time value exceeds 1 second, it is not desirable.

[0045] When carrying out short-time charge for 1 or less second for presumption, as for a current value, it is desirable that it is the current rate of 0.05 or more C. 0. In the charging current of a small current rate, it becomes small greatly electrical-potential-difference changing the reading error of terminal voltage, increase of a presumed error will be caused, and it is not more desirable than 05C.

[0046] Similarly, when carrying out short-time discharge for 1 or less second for presumption, as for a current value, it is desirable that it is the current rate of 0.5 or more C. 0. In the discharge current of a small current rate, it becomes small greatly electrical-potential-difference changing the reading error of terminal voltage, increase of a presumed error will be caused, and it is not more desirable than 5C.

[0047] Terminal voltage Voc1 before charge or discharge It is desirable that it is the electrical potential difference for less than 2 seconds which a test objective cel or a group cell sets to hibernation and by which charge or discharge is started. Relation with the cell condition which the condition of a trial cell changed and carried out charge and discharge in the terminal voltage before exceeding 2 seconds, charge or discharge starting, becomes complicated and is not desirable.

[0048] Moreover, terminal voltage Voc3 recorded after charge or discharge termination It is this better ** that it is an electrical potential difference for less than 2 seconds after charge or discharge termination. In the terminal voltage after exceeding 2 seconds, the condition inside a trial cell changes a lot, and it is Voc1. V2 Since relation becomes complicated and increase with error is caused, it is not desirable.

[0049] The equipment which performs discharge possible capacity from a full charge condition, and residue presumption with the application of the cell capacity and the residue presumption approach of becoming this invention It consists of a computer which manages data, and a charge-and-discharge machine which controls the test condition of a cell. It is characterized by performing capacity of a trial cel or a group cell, and residue presumption according to the procedure of building the circuit or function calculated based on this cell capacity, the degradation judging type in the residue presumption approach, and an electrical-potential-difference-capacity curve (relational expression) in this computer, and indicating it above.

[0050] Although an example of the construct of this capacity and residue presumption equipment is shown in drawing 3 , if the execution function of test control, data collection, cell capacity, and residue presumption is satisfied, a configuration will not be limited to this at all.

[0051] Drawing 3 shows an example of the concept which has arranged the test objective cel or group cell of 1 to the testing device of 12. A testing device 12 consists of computers 3 which perform control of the charge-and-discharge machine 2 which performs activation of concrete charge and discharge in order to examine this trial cell 1, and this charge-and-discharge machine, storage, and record.

[0052] The charge-and-discharge machine 2 consists of constant current load equipment 4, a constant current constant voltage power supply 5, and switches S1 and S2. Constant current load equipment 4 fluctuates a load so that the current supplied from the trial cell 1 may be

maintained by the fixed set point. The constant current constant voltage power supply 5 operates as a constant current source, and after it reaches a programmed voltage, it operates as a constant voltage power supply, until it reaches a programmed voltage, when charge and discharge are prescribed for a fixed time amount.

[0053] CPU6, charge-and-discharge control and data logging by which a computer 3 controls the whole trial, Others [ROM / 7 / by which the program of the degradation criterion type about the cell capacity and the residue presuming method of this invention or electrical-potential-difference-capacity relational expression (curve) is furthermore contained beforehand], A judgment type is created with the procedure furthermore indicated from this criteria type to the above. It consists of the working-level month RAM 8 which performs capacity and residue presumption to this degradation judging type and electrical-potential-difference-capacity relational expression with the application of a test data and a printer 9, a keyboard 10, and a drop 11 that displays a charge-and-discharge condition and a test result.

[0054] According to the program stored in ROM7, CPU6 controls the constant current constant voltage power supply 5 of the charge-and-discharge machine 2, constant current load equipment 4, a switch S1, and the whole equipment of S2**. The set point required for each characteristic test etc. is inputted by the keyboard 10.

[0055] In a computer 3, controlling a trial in the conditions set up beforehand, data, such as temperature, humidity, and cell distortion, are measured and memorized to the terminal voltage of the trial cell 1, a current, and a pan with a predetermined time interval if needed, and it records on them further. Moreover, the calculation function which applies a criteria type to the obtained test data, creates a judgment type, presumes the discharge possible capacity from the full charge condition of a test objective cell or a group cell, applies to electrical-potential-difference-capacity relational expression, and performs residue presumption, and the property creation function which will plot a test data for every fixed time amount if still more nearly required are provided.

[0056] The capacity and the residue presumption function of an alkaline battery which become this invention With the computer which calculates in order to carry out collection management of the test data and to calculate capacity and residue estimate according to the above-mentioned procedure, if required [whether it consists of a discharge current controller which controls the test discharge conditions of this trial cell, or a charge-and-discharge controller, and] Or if it extends and comes to carry the arithmetic circuit which performs the procedure of the cell capacity indicated above and the residue presuming method, or a function in an established computer and is required for it It is characterized by consisting of a discharge current controller or a charge-and-discharge controller, including in an existing non-cut [the electric current] off electric supply system and an existing rechargeable battery charge-and-discharge automatic test equipment, and giving the function [**** / the former] which, in addition, enables capacity of a test objective cell, and residue presumption.

[0057] Therefore, as much as possible, this trial cell capacity and the residue presumption function which become this invention spoil existing equipment or the function of system original, or are not making it fall and perform capacity and residue presumption.

[0058] The construct which gave the cell capacity and the residue presumption function which become this invention as an example to the non-cut [the electric current] off electric supply system is shown in drawing 4 .

[0059] Drawing 4 shows an example of the non-cut [the electric current] off electric supply structure-of-a-system concept constituted by arranging the cell capacity which becomes this invention, and the computer control section of a residue presumption function inside a power converter, and connecting.

[0060] In drawing 4 , the basic configuration of a non-cut [the electric current] off electric supply system is made with the trial cell of 1 or a group cell, the alternating current of 13 or DC power supply, the power converter of 14, and the load equipment of 15. The main conversion circuit 16 is carried in the power converter of 14, and the alternating current from a power source 13 or direct current power is changed.

[0061] The cell capacity and the residue presumption function in this invention consist of switches 18 separated from a main circuit at the time of a computer 3, the constant current control circuit 17, and a trial.

[0062] The computer 3 which constitutes the capacity and the residue presumption function of this invention CPU6, test control and data logging which control the discharge for capacity and residue presumption, or the whole charge trial, Others [ROM /7 / by which the program of the criteria type about the cell capacity and the residue presuming method of this invention and relational expression is furthermore contained beforehand], It consists of the working-level month RAM 8 which applies to a test data, creates a judgment type, performs capacity presumption, applies to electrical-potential-difference-capacity relational expression, and performs residue presumption with the procedure which furthermore indicated this criteria type above and a printer 9, a keyboard 10, and a drop 11 that displays a discharge condition and a test result. A drop 11 can be attached also in the part which the operator of the wall surface of a power converter 14 other than this computer 3 tends to recognize in consideration of the convenience on use.

[0063] In addition, if the function of capacity presumption which the construct shown in drawing 4 is a strictly concrete example, and was mentioned above was held and it is equipped fully with the component, the configuration which gives this capacity presumption function to a non-cut [the electric current] off electric supply system or the other equipment will not be limited to this at all.

[0064] Although an example explains the cell capacity and the residue presumption approach of becoming this invention below, this invention is not limited to these at all.

[0065]

[Example] While collecting the trickle single nickel-cadmium batteries (nominal capacity QB=4Ah) used for the [example 1] emergency light, the new article cell of isomorphism was purchased and internal resistance and capacity were evaluated.

[0066] The carried-out trial is as follows.

[0067] That is, each cell collected or purchased is installed in cell charge and discharge test equipment, and it charges with the current value of 0.1CmA (400mA) for 16 hours, and discharges to 1.0V with the current value of 0.2CmA (800mA) after a 1-hour pause, and the pause of 1 hour is performed. By hibernation just before repeating this twice and starting the 3rd discharge, short-time discharge of 10msec(s) was performed with the current value of 1.0CmA (4000mA), and the magnitude of the electrical-potential-difference response was measured. The electrical-potential-difference response adopted the difference of terminal voltage just before carrying out short-time discharge and ending short-time discharge. The pause of 1 hour was placed after this short-time discharge, it discharged to 1.0V by the constant current of 0.2CmA (800mA), and this capacity was made into cell capacity. The value which *(ed) magnitude of an electrical-potential-difference response with the current value was made into internal resistance.

[0068] In this way, if the capacity Q of each measured cell is plotted about the logarithm of internal resistance Z, good straight-line relation will be obtained, and it is the relation. $Q = -1291 \times \ln(Z) + 8490$ (4) It became and this was made into the degradation criterion type.

[0069] next, the trickle used as a test objective — AA — purchasing the new article of 3 cel serial pack (nominal capacity 600mAh) of a nickel-cadmium battery, the current value examined on the same conditions as the above except having set short-time discharge calculating 0.1CmA (s) (60mA) for charge, and calculating discharge for 0.2CmA(s) (120mA) and internal resistance to 1.0CmA(s) (600mA), and calculated capacity QA =642 and internal resistance ZA =65.25. a basis [values / these] — multiplier a=-1291 of a degradation criterion type (4), and b= 8490 — amending — $Q = a(QA/QB) \ln(Z) + QA - a(QA/QB) \ln(ZA) = -174 \times \ln(Z) + 1368$ (5) a trickle — AA — the degradation judging type of 3 cel serial pack of a nickel-cadmium battery was obtained.

[0070] After carrying out the above-mentioned trial and charging this cell pack by 0.1CmA(s) (60mA) for 16 hours, a pause is placed for 1 hour, and it is terminal voltage Voc1. After measuring, short-time discharge of 600mA and 10msec is carried out, and it is terminal voltage V2 just before discharge termination. It measured and internal resistance $Z1 = (Voc1 - V2) / 600$ were calculated like the above-mentioned approach. Then, after carrying out discharge for 30 minutes (60mAh) by 0.2CmA (120mA), the pause of 2 hours is set, and it is terminal voltage Vocx. After measuring, short-time discharge of 600mA and 10msec was carried out again, terminal voltage Vx2 was measured, this was ended, and internal resistance $Zx = (Vocx - Vx2) / 600$ were calculated like the above-mentioned approach.

[0071] This 30-minute discharge, a 2-hour pause, and terminal voltage Vocx Actuation of measurement, 10msec discharge, and terminal voltage Vx2 measurement was repeated until the electrical potential difference at the time of discharge resulted in 3.0V (1.0V/cel). Shortly after discharge voltage resulted in 3.0V (1.0V/cel), discharge was ended, it asked for internal resistance on the same conditions as the above after the pause of 2 hours.

[0072] In this way, pause electrical potential difference Vocx just before choosing the data of four discharge conditions among the test datas for which it asked and carrying out each short-time discharge Internal resistance Zx From the above-mentioned $QA=642 \times \frac{Q}{QA} \left\{ \frac{\ln(Z)+dV-e}{fV-g} \right\}$ (3) (d, e, f, and g are a constant) constants d, e, f, and g — computing — $Q=642 \times \left\{ \frac{\ln(Z)+15.1V-11.3}{(0.15V-0.208)} \right\}$ (6) Another degradation judging type was created. This judgment type (6) $Voc1 < (Q/QA) \times 2.55 (V \times 0.853 \text{ cels})$ (7) When becoming, it decided to use it instead of the above-mentioned degradation judging type (5).

[0073] Moreover, pause electrical potential difference Voc1 in each discharge condition that the terminal voltage in the discharge for which it asked by the above-mentioned trial results in 3.0V Relation with the total amount of discharge from a full charge and an electrical-potential-difference-capacity curve were plotted beforehand, and the basic data for the residue calculation shown in drawing 5 was obtained.

[0074] Drawing 5 is the terminal voltage Voc1 of the cell pack which is the basic data used in order to presume the residue of this trial cell pack, and was examined as an example. When it is the value shown in drawing 5, the value is applied to a curve, and it is the capacity Q1 from a full charge. It asks. A difference with the initial capacity QA, $Qr0=QA-Q1$ (8) Let Qr0 be a residue in the case of non-deteriorated elegance. Moreover, this residue $100 \times (Qr0/QA)$ (9) It can carry out and percent can also show.

[0075] In this way, capacity of the collected trickle single nickel-cadmium-battery pack (3 cel serial, nominal capacity 600mAh) and residue presumption were performed based on the basic data of the obtained degradation judging type (5), (6), and electrical-potential-difference-capacity.

[0076] It charges by 0.1CmA(s) (60mA) first for 16 hours, and the collected cell pack places the pause of 1 hour. Terminal voltage Voc1 After measuring, short-time discharge of 10msec(s) is performed by 1.0CmA (600mA), and it is the electrical potential difference V2 in front of discharge termination. It measures and internal resistance $Z=\Delta V/I = (Voc1-V2) / 600$ are calculated.

[0077] It is open-circuit voltage Voc1 at 0.2CmA (120mA) after stopping this cell pack for 2 hours. It discharges until it becomes under 3.75V (1.25V/cel) more than 3.60V (1.20V/cel). Terminal voltage Voc1 and internal resistance Z are measured in the same procedure as the above after the pause of 1 hour.

[0078] It is open-circuit voltage Voc1 at the current value of 0.2CmA (120mA) after stopping for further 2 hours. It discharges until it becomes under 3.60V (1.20V/cel) more than 3.30V (1.10V/cel), and they are after a 2-hour pause and terminal voltage Voc1 similarly. Internal resistance is measured.

[0079] In this way, measured terminal voltage Voc1 Internal resistance was substituted for a degradation judging type (5) or (6) in consideration of relational expression (7), and the discharge possible capacity Q from a full charge was computed.

[0080] Furthermore, this trial cell pack discharges to terminal voltage 3.0V (1.0V / cel) by 0.2CmA (120mA), calculates the total capacity from a full charge, and is the observation capacity Qm about this. It carried out. the presumed capacity Q and observation capacity Qm from — $Err=100 \times (Q-Qm)/Qm$ (10) It computed and this was made into Error Err.

[0081] A result is shown in drawing 6.

[0082] Drawing 6 is drawing to the discharge possible capacity from the surveyed full charge condition having shown the error searched for with the relation of the above (10). In drawing 6, a white round head is as a result of [of the trial cell pack in a full charge condition] measurement, and a rectangular head is terminal voltage Voc1. It is as a result of [of the trial cell pack in the discharge condition below more than 3.60V3.75V] measurement, and a black dot is terminal voltage Voc1. It is as a result of [of the trial cell pack in the discharge condition below more than 3.30V3.60V] measurement.

[0083] Compared with the capacity which surveyed discharge possible capacity from the full

charge presumed by the approach of becoming this invention, it turned out to all the capacity (degradation condition) of the cell pack used as the measuring object that they are less than **15% of errors, and a good presumed precision so that clearly [drawing 6].

[0084] Furthermore, terminal voltage V_{oc1} The residue Q_{r0} obtained from the relation of the electrical-potential-difference-capacity which applied to the electrical-potential-difference-capacity curve (relation) which shows a value to drawing 5 , and was shown in above-mentioned drawing 5 by (8) types, the presumed capacity Q from a full charge which can be discharged and the initial capacity Q_A which were obtained by a degradation judging type (5) and (6) at this from — $Q_r = Q_{r0} (Q/Q_A)$ (11) The residue of a trial cell was presumed. It compares with the observation residue Q_{rm} which measured this by the approach shown above. $Err(r) = 100 \times (Q_r - Q_{rm})/Q_{rm}$ (12) It carried out and the error was searched for.

[0085] A result is shown in drawing 7 . Drawing 7 is the error Err of the presumed residue calculated by (12) formulas to an observation residue about the three cell pack in an examined different degradation condition (r). A result is shown.

[0086] As shown in drawing 7 , each presumed residue measured in the state of discharge was less than **10% of error compared with the actual measurement, it was highly precise and the approach of becoming this invention showed that it could presume a residue.

[0087] The result of the cell pack examined in the [example 2] example 1 is used, and it is the terminal voltage V_{oc1} in each discharge condition. Judgment precision of the discharge possible-capacity presumption Q from a full charge for which it asked from the degradation judging type (5) in an example 1 and (6) was examined.

[0088] Terminal voltage V_{oc1} of the trial cell pack used as the criteria for use of food additives of a degradation judging type (6) Capacity Q_A of non-deteriorated elegance Relation with the presumed capacity Q calculated from the degradation judging type (5) $J = V_{oc1} (Q/Q_A)$ (13) The value was changed and the magnitude of a judgment error was investigated.

[0089] A result is shown in drawing 8 .

[0090] Drawing 8 shows the error range to the value J calculated by the formula (13) which is the decision criterion which uses the degradation judging type (6) shown in the above-mentioned example 1.

[0091] It turned out that the error over the observation capacity of presumed capacity when the value of J uses a degradation judging type (6) less than by 2.55 becomes small compared with the case where the value of J uses a ** (6) type or more by 2.55, and capacity presumption is attained in a good precision so that clearly from drawing 8 .

[0092] a [example 3] trickle — AA — the electrical-potential-difference-capacity curve was created in order to presume the residue of a nickel cadmium cel (nominal capacity 600mAh).

[0093] Once charging this by 0.1CmA(s) (60mA) about non-deteriorated elegance 10 cel of a test objective for 16 hours, The open circuit terminal voltage V_{oc} is recorded, and it discharges on the conditions which show this to drawing 11 , sets to hibernation, and is the open circuit terminal voltage V_{ocx} to the last of relaxation time. It records. It is made to discharge on the same conditions again, this is repeated to the electrical potential difference not more than 1.0V, and they are V_{oc} and V_{ocx} . It plotted to every charging time value (discharge capacity).

[0094] a trickle — AA, while presuming the discharge possible capacity from a full charge condition like an example 1, after collecting 100 cels (nominal capacity 600mAh) of nickel cadmium cels and charging by the current rate of 0.1CmA (60mA) for 16 hours It is the open circuit terminal voltage V_{oc1} like an example 1. Ten every cels each are applied to the above-mentioned electrical-potential-difference-capacity curve which created the presumed capacity Q about each non-deteriorated elegance cel, and it is a residue Q_r . While presuming, the observation residue Q_{rm} was also calculated collectively. (12) By the formula, the presumed error was computed and the maximum of the absolute value was shown in drawing 11 .

[0095] The current rate of 0.1CmA (60mA) and 0.2CmA (120mA) and the time amount of each discharge had [the conditions of the discharge which creates an electrical-potential-difference-capacity curve] 0.5 or less desirable hours, and the quiescent time after each discharge was understood that it is desirable that it is 1 hours or more so that clearly from the maximum of the absolute error shown in drawing 11 .

[0096] five trickles same with having used for the [example 4] example 1 — AA — the nickel-cadmium-battery pack (3 cel serial) new article was purchased, and the degradation judging type

was drawn from the degradation criterion type (4) for which it asked in the above-mentioned example 1.

[0097] That is, after charging this cell pack by the current rate of 0.1CmA(s) (60mA) for 16 hours and stopping for 1 hour, it discharges to 3.0V (1.0V/cel) by the current rate of 0.2CmA (120mA), and a pause is performed for 1 hour. This charge and discharge were repeated twice, and it charged and stopped on the still more nearly same conditions. Before discharging, it is terminal voltage Voc1. Terminal voltage V2 just before measuring, and only the time amount t shown in drawing 12 carrying out short-time discharge by current value 1.0CmA (600mA) and ending this discharge It measured. After setting the pause of 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and it is capacity QA from this discharge. It asked. Internal resistance ZA It asked from $ZA = (Voc1 - V2) / 600$. Based on these values, the value which amends multiplier $a = -1291$ of a degradation criterion type (4) and $b = 8490$, and shows multiplier a' of a degradation judging type (2) and b' to decision and drawing 12 by the following formulas was acquired.

[0098]

$a' = a (QA/QB)$ (14) $b' = QA - a(QA/QB) \ln(ZA)$ (15) After that, this cell pack was charged by the current rate of 0.1CmA(s) (60mA) for 16 hours, and it stopped for 1 hour. Then, terminal voltage Voc1 Terminal voltage V2 just before measuring, and only the time amount t shown in drawing 12 carrying out short-time discharge by current rate 1.0CmA (600mA) and ending this discharge It measured. After setting the pause of 1 hour, it discharged for 30 minutes by the current rate of 0.2CmA (120mA), and the pause of 2 hours was set. Open-circuit voltage [in / if a pause is completed for 2 hours, terminal voltage will be measured, and / depth of discharge x] Vocx It carried out. And operation and terminal voltage Vx2 were again measured for short-time discharge of these conditions, and short-time discharge was ended.

[0099] They are discharge, a 2-hour pause, and terminal voltage Vocx for these 30 minutes until the terminal voltage under discharge reaches 3.0V (1.0V/cel). The procedure of measurement, short-time discharge, and terminal voltage Vx2 measurement was repeated. Vocx in each of such depth of discharge x $Zx = (Vocx - Vx2) / I$ and capacity QA from — the value which shows the multipliers d, e, f, and g of another degradation judging type (3) to decision and drawing 12 R> 2 was acquired.

[0100] thus, the trickle collected based on two created degradation judging types — AA — it applied to the judgment type created from each non-deteriorated elegance ten every packs each about nickel-cadmium-battery pack (3 cel serial, nominal capacity 600mAh) 50 pack, and capacity presumption and actual volumetry were performed like the example 1.

[0101] A result is shown in drawing 12 . namely, the presumed capacity Q and the observation capacity Qm which were measured to drawing 12 from — the max of the absolute value of the acquired error is shown and the short-time charging time value t became clear [that capacity presumption with it can be performed] in 1 or less second. [a small error and] [highly precise]

[0102] five trickles same with having used for the [example 5] example 1 — AA — the nickel-cadmium-battery pack (3 cel serial) new article was purchased, and the degradation judging type was drawn from the degradation criterion type (4) for which it asked in the above-mentioned example 1.

[0103] That is, after charging this cell pack by the current rate of 0.1CmA(s) (60mA) for 16 hours and stopping for 1 hour, it discharges to 3.0V (1.0V/cel) by the current rate of 0.2CmA (120mA), and a pause is performed for 1 hour. This charge and discharge were repeated twice, and it charged and stopped on the still more nearly same conditions. Before discharging, it is terminal voltage Voc1. Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time discharge with each current value I shown in drawing 13 and ending this discharge It measured. After setting the pause of 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and it is capacity QA from this discharge. It asked. Internal resistance ZA It asked from $ZA = (Voc1 - V2) / I$. Based on these values, the value which amends multiplier $a = -1291$ of a degradation criterion type (4) and $b = 8490$, and shows multiplier a' of a degradation judging type (2) and b' to decision and drawing 13 by the following formulas was acquired.

[0104]

$a' = a (QA/QB)$ (14) $b' = QA - a(QA/QB) \ln(ZA)$ (15) After that, this cell pack was charged by the

current rate of 0.1CmA(s) (60mA) for 16 hours, and it stopped for 1 hour. Then, terminal voltage Voc1 Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time discharge by each current rate shown in drawing 13 and ending this discharge It measured. After setting the pause of 1 hour it discharged for 30 minutes by the current rate of 0.2CmA (120mA), and the pause of 2 hours was set. Open-circuit voltage [in / if a pause is completed for 2 hours, terminal voltage will be measured, and / depth of discharge x] Vocx It carried out. And operation and terminal voltage Vx2 were again measured for 10msec short-time discharge, and short-time discharge was ended.

[0105] They are discharge, a 2-hour pause, and terminal voltage Vocx for these 30 minutes until the terminal voltage under discharge reaches 3.0V. Measurement, 10msec short-time discharge, and terminal voltage Vx2 measurement were repeated. Vocx in each of such depth of discharge $x \quad Zx = (Vocx - Vx2) / I$ and capacity QA from — the value which shows the multipliers d, e, f, and g of another degradation judging type (3) to decision and drawing 13 was acquired.

[0106] thus, the trickle which used and collected the charge and discharge test equipment which possesses the capacity and the residue judging function which is shown in drawing 3, and which becomes this invention based on two degradation judging types which created — AA — ten every packs applied to the degradation judging type which created from each sheep degradation article like an example 1 about nickel-cadmium-battery pack (3 cel serial, nominal-capacity 600mAh) 50 pack, and capacity presumption and actual volumetry carried out.

[0107] A result is shown in drawing 13. namely, the presumed capacity Q and the observation capacity Qm which were measured to drawing 13 from — the max of the absolute value of the acquired error is shown and it became clear that the current value of 10msec short-time discharge can perform capacity presumption with it. [a small error and] [highly precise in 0.5 or more CmAs]

[0108] five trickles same with having used for the [example 6] example 1 — AA — the nickel-cadmium-battery pack (3 cel serial) new article was purchased, and the degradation judging type was drawn from the degradation criterion type (4) for which it asked in the above-mentioned example 1.

[0109] That is, after charging this cell pack by the current rate of 0.1CmA(s) (60mA) for 16 hours and stopping for 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and a pause is performed for 1 hour. This charge and discharge were repeated twice, and it charged and stopped on the still more nearly same conditions. Before discharging, it is terminal voltage Voc1. Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time charge with each current value I shown in drawing 14 and ending this charge It measured. After setting the pause of 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and it is capacity QA from this discharge. It asked. Internal resistance ZA It asked from $ZA = (V2 - Voc1) / I$. Based on these values, the value which amends multiplier a=1291 of a degradation criterion type (4) and b= 8490, and shows multiplier a' of a degradation judging type (2) and b' to decision and drawing 14 by the following formulas was acquired.

[0110]

$a' = a (QA / QB)$ (14) $b' = QA - a(QA / QB) \ln(ZA)$ (15) Terminal voltage Voc1 of this after that and cell pack Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time charge by each current rate shown in drawing 14 R> 4 and ending this charge It measured. the current rate of 0.1CmA (60mA) after setting the pause of 1 hour — 1 hour — charging — 1 hour — it stopped. Open-circuit voltage [in / if a pause is completed for 1 hour, terminal voltage will be measured, and / the charge condition X] Vocx It carried out. And operation and terminal voltage Vx2 were again measured for 10msec short-time discharge, and short-time discharge was ended.

[0111] They are this 1-hour discharge, a 1-hour pause, and terminal voltage Vocx until the total time amount of charge reaches in 16 hours. Measurement, 10msec short-time charge, and terminal voltage Vx2 measurement were repeated. Vocx in each of these charge conditions X $Zx = (Vx2 - Vocx) / I$ and capacity QA from — the value which shows the multipliers d, e, f, and g of another degradation judging type (3) to decision and drawing 14 was acquired.

[0112] Thus, the charge and discharge test equipment possessing the capacity and the residue judging function which applied two created degradation judging types, which are shown in drawing 3 and which become this invention is used. Nickel-cadmium-battery pack (3 cel serial, nominal

capacity 600mAh) 50 pack ten packs [every] each is applied. the collected trickle — AA — The same procedure as an example 1 performed capacity presumption and actual volumetry except performing short-time charge with the value which a current rate shows to drawing 14 instead of the short-time charge shown in the example 1.

[0113] A result is shown in drawing 14 . namely, the presumed capacity Q and the observation capacity Qm which were measured to drawing 14 from — the max of the absolute value of the acquired error is shown and it became clear that the current value of 10msec short-time discharge can perform capacity presumption with it. [a small error and] [highly precise in 0.05 or more CmAs]

[0114] five trickles same with having used for the [example 7] example 1 — AA — the nickel-cadmium-battery pack (3 cel serial) new article was purchased, and the degradation judging type was drawn from the degradation criterion type (4) for which it asked in the above-mentioned example 1.

[0115] That is, after charging this cell pack by the current rate of 0.1CmA(s) (60mA) for 16 hours and stopping for 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and a pause is performed for 1 hour. This charge and discharge were repeated twice, and it charged and stopped on the still more nearly same conditions. 2 seconds before discharge starting, it is terminal voltage Voc1. Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time discharge by the current rate of 1.0CmA (600mA) and ending this discharge It measured. After setting the pause of 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and it is capacity QA from this discharge. It asked. Internal resistance ZA It asked from $ZA = (V2 - Voc1) / I$. Based on these values, the value which amends multiplier a = -1291 of a degradation criterion type (4) and b = 8490, and shows multiplier a' of a degradation judging type (2) and b' to decision and the following by the following formulas was acquired.

[0116] $-174 = a(QA / QB)$

$1368 = QA - a(QA / QB) \ln(ZA)$

Then, this cell pack was charged by the current rate of 0.1CmA(s) (60mA) for 16 hours, and it stopped for 1 hour. Then, it is terminal voltage Voc1 2 seconds before discharge starting. Terminal voltage V2 just before measuring, and 10msec's carrying out between short-time discharge by the current rate of 1.0CmA (600mA) and ending this discharge It measured. After setting the pause of 1 hour, it discharged for 30 minutes by the current rate of 0.2CmA (120mA), and the pause of 2 hours was set. Open-circuit voltage [in / if a pause is completed for 2 hours, terminal voltage will be measured 2 seconds before / next / discharge starting and / depth of discharge x] Vocx It carried out. And operation and terminal voltage Vx2 were again measured for 10msec short-time discharge, and short-time discharge was ended.

[0117] They are discharge, a 2-hour pause, and terminal voltage Vocx for these 30 minutes until the terminal voltage under discharge reaches 3.0V. Measurement, 10msec short-time discharge, and terminal voltage Vx2 measurement were repeated. Vocx in each of such depth of discharge x $Zx = (Vocx - Vx2) / I$ and capacity QA from — the multipliers d, e, f, and g of another degradation judging type (3) — decision — d = 15.1, e = -11.3, f = 0.15, and g = 0.208 were obtained, respectively.

[0118] thus, the trickle collected based on two created degradation judging types — AA — terminal voltage measurement was carried out to the predetermined time amount before short-time discharge about nickel-cadmium-battery pack (3 cel serial, nominal capacity 600mAh) 10 pack, and also capacity presumption and actual volumetry were performed like the example 1.

[0119] A result is shown in drawing 9 . That is, in drawing 9 , it is terminal voltage Voc1. It is drawing having shown the relation of the time amount and error range which measured before short-time discharge starting. the presumed capacity Q and the observation capacity Qm which were measured so that clearly from drawing 9 from — when the acquired error carried out terminal voltage measurement for less than 2 seconds before short-time discharge starting, it turned out that an error becomes small and can perform highly precise capacity presumption compared with the case where terminal voltage is measured by the time amount exceeding 2 seconds before initiation.

[0120] five trickles same with having used for the [example 8] example 1 — AA — the nickel-cadmium-battery pack (3 cel serial) new article was purchased, and the degradation judging type was drawn from the degradation criterion type (4) for which it asked in the above-mentioned

example 1.

[0121] That is, after charging this cell pack by the current rate of 0.1CmA(s) (60mA) for 16 hours and stopping for 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and a pause is performed for 1 hour. This charge and discharge were repeated twice, and it charged and stopped on the still more nearly same conditions. Next, terminal voltage V2 just before 10msec carries out between short-time discharge and ending this discharge by the current rate of 1.0CmA(s) (600mA) It measures and is the terminal voltage Voc3 at the time of this 2-second progress after discharge termination. It measured. After setting the pause of 1 hour, it discharges to 3.0V by the current rate of 0.2CmA (120mA), and it is capacity QA from this discharge. It asked. Internal resistance ZA It asked from $ZA = (V2 - Voc1) / I$. Based on these values, the value which amends multiplier $a = -1291$ of a degradation criterion type (4) and $b = 8490$, and shows multiplier a' of a degradation judging type (2) and b' to decision and the following by the following formulas was acquired.

[0122] $-174 = a(QA / QB)$

$1370 = QA - a(QA / QB) \ln(ZA)$

Then, this cell pack was charged by the current rate of 0.1CmA(s) (60mA) for 16 hours, and it stopped for 1 hour. Then, terminal voltage V2 just before 10msec carries out between short-time discharge and ending this discharge by the current rate of 1.0CmA (600mA) It measures and is the terminal voltage Voc3 at the time of this 2-second progress after discharge termination. It measured. After setting the pause of 1 hour, it discharged for 30 minutes by the current rate of 0.2CmA (120mA), and the pause of 2 hours was set. Open-circuit voltage [in / if a pause is completed for 2 hours, operation and terminal voltage Vx2 will be again measured for 10msec short-time discharge, short-time discharge will be ended, and terminal voltage is measured by progress for after / termination / 2 seconds, and / depth of discharge x] Vocx It carried out.

[0123] They are discharge, a 2-hour pause, 10msec short-time discharge, terminal voltage Vx2 measurement, and terminal voltage Vocx for these 30 minutes until the terminal voltage under discharge reaches 3.0V. Actuation of measurement was repeated. Vocx in each of such depth of discharge x $Zx = (Vx2 - Vocx) / I$ and capacity QA from — the multipliers d, e, f, and g of another degradation judging type (3) — decision — $d = 15.0$, $e = -11.4$, $f = 0.15$, and $g = 0.210$ were obtained, respectively.

[0124] thus, the trickle which used and collected the charge and discharge test equipment possessing the capacity and the residue judging function which applied two created degradation judging types, which are show in drawing 3, and which becomes this invention — AA — carried out terminal voltage measurement by the predetermined time progress after short-time discharge termination about nickel-cadmium battery pack (3 cel serial, nominal capacity 600 mAh) 10 pack, and also capacity presumption and actual volumetry carried out like an example 1.

[0125] A result is shown in drawing 10. That is, drawing 10 is terminal voltage Voc3. It is drawing having shown the relation of the predetermined time of day after short-time discharge termination and error range which measured.

[0126] the presumed capacity Q and the observation capacity Qm which were measured so that clearly from drawing 10 from — the acquired error — terminal voltage Voc3 for less than 2 seconds after short-time discharge termination the time amount which exceeds 2 seconds after termination when measuring — terminal voltage Voc3 It turned out that an error becomes small and highly precise capacity presumption can be performed compared with the case where it measures.

[0127]

[Effect of the Invention] As stated above, according to this invention, the discharge possible capacity from a full charge condition and a residue will be comparatively highly precise in a short time, it can presume, a raise in reliance of backup power supplies, such as a non-cut [the electric current] off electric supply system, and efficient maintenance implementation can be expected, and a big contribution will be achieved.

【特許請求の範囲】

【請求項1】 アルカリ蓄電池（以下、セルと呼称）、または直列に複数個接続されたアルカリ蓄電池群（以下、組電池と呼称）に関して、試験対象セル、あるいは組電池をいったん休止状態においた後、一定電流値で短時間放電、または充電して、その放電または充電前後の端子電圧の変化から内部抵抗を求め、この内部抵抗と休止状態における開回路電圧とを、容量と内部抵抗と開回路電圧とからなる劣化判定基準式を試験対象の新品電池の内部抵抗と公称容量によって係数補正した判定式に適用して、満充電からの放電可能容量を推定すると同時に、放電、あるいは充電前後の休止状態における開回路電圧と該公称容量と推定容量とを、電圧－容量曲線に適用して残量を推定することとを特徴とするアルカリ蓄電池容量残量推定法。

【請求項2】 セル、あるいは組電池の端子電圧をモニタしながらこれをいったん休止状態に置き、端子電圧 V_{oc1} を記録した後、一定の電流値 I で短時間放電、あるいは充電を行い、その放電、充電直後の端子電圧 V_2 を記録してその電圧差

$$\Delta V = V_{oc1} - V_2$$

を放電、あるいは充電電流値で除した値 Z

$$Z = \Delta V / I$$

を内部抵抗として求め、

あるいは、一定の電流値 I で短時間放電、あるいは充電

$$Q = a \ln(Z) + b \quad (a, b \text{ は定数、} a < 0) \quad (1)$$

であり、該基準式 (1) の定数 a 、 b について、試験対象セルあるいは組電池の新品（未劣化品）の容量 Q_A と $Z_A = \Delta V / I$ の内部抵抗 Z_A とを用いて、

$$a \rightarrow a(Q_A / Q_B)$$

$$Q = a(Q_A / Q_B) \ln(Z) + Q_A - a(Q_A / Q_B) \ln(Z_A) \quad (2)$$

を劣化判定式として用い、該判定式 (2) に、内部抵抗 Z 、または Z' を代入して算出した値 Q を、満充電状態からの放電可能容量とし、

さらに、試験対象セル、あるいは組電池の開回路電圧 V_{oc1} 、または V_{oc3} と、上記劣化判定式 (2) において算出した Q の値と、該当する未劣化品の容量 Q_A との関係が

$$Q = Q_A \{ [\ln(Z) + dV - e] / (fV - g) \} \quad (3)$$

(d, e, f, g は定数)

について、定数 d, e, f, g を、未劣化品について異なる4段階の放電深度まで放電させて求めた開回路電圧と内部抵抗の値と、 $Q = Q_A$ とから決定してこれを用い、該判定式 (3) に、開回路電圧 V_{oc1} 、または V_{oc3} と、内部抵抗 Z 、または Z' とを代入して算出した値 Q を、満充電状態からの放電可能容量とし、一方、残量を推定するために使用する電圧－容量曲線は、試験対象の満充電状態におかれた新品セルの開回路端子電圧 V_o を記録した後これを、0.1C、ないし0.2Cの電流

を行い、その放電、充電が終了し休止に入った直後の端子電圧 V_{oc3} を記録してその電圧差

$$\Delta V' = V_2 - V_{oc3}$$

を放電、あるいは充電電流値で除した値 Z'

$$Z' = \Delta V' / I$$

を内部抵抗として求め、

あらかじめ異なる劣化状態のセル特性から求めておいた劣化判定基準式の定数補正を実施してこれに適用して、該試験対象セル、あるいは組電池の満充電状態からの放電可能容量 Q を推定すると同時に、

上記の短時間充電、あるいは放電を実施する前の休止時の端子電圧 V_{oc1} 、あるいは実施直後の休止時の端子電圧 V_{oc3} を、あらかじめ求めておいた該試験対象の新品セルの電圧－容量曲線に適用して算出した残量（放電残時間） Q_{r0} と上記短時間充電、あるいは放電によって推定された満充電状態からの放電可能容量 Q と該試験対象セル、あるいは組電池の公称容量 Q_o とから、残量（放電残時間） Q_r を

$$Q_r = Q_{r0} (Q / Q_o)$$

によって推定することとを特徴とする請求項1記載のアルカリ蓄電池容量残量推定法。

【請求項3】 試験対象セル、あるいは組電池の満充電状態からの放電可能容量を求める方法において、算出の基本となる劣化判定基準式が、内部抵抗 Z の対数と容量 Q とから構成される式

$$b \rightarrow Q_A - a(Q_A / Q_B) \ln(Z_A) \quad (Q_B \text{ は基準式作成のために用いたセルの容量})$$

となるように変換した式、

$$V_{oc1} (Q / Q_A) < 0.85 \times (\text{セル数})$$

または、

$$V_{oc3} (Q / Q_A) < 0.85 \times (\text{セル数})$$

となる場合には、この Q 値を用いずに、劣化判定式 (2) の代わりに、内部抵抗 Z と開回路電圧 V とで表される容量 Q の式、

率で30分以下の一定時間で放電し、これを1時間以上の休止状態におき休止時の最後に開回路端子 V_{ox} を記録して、再び同一条件で放電させ、これを1.0V以下の電圧まで繰り返して V_o と V_{ox} とを、放電時間（放電容量）ごとにプロットして求めた曲線であることを特徴とする請求項2記載のアルカリ蓄電池容量残量推定法。

【請求項4】 請求項2記載のアルカリ蓄電池容量残量推定法において、試験対象セル、あるいは組電池の満充電状態からの放電可能容量を求めるために実施される端

子電圧の記録と、充電、あるいは放電条件が、充電、あるいは放電前の端子電圧 V_{oc1} は試験対象セル、あるいは組電池が休止状態におかれ充電、あるいは放電が開始される2秒以内の電圧であり、

充電は0.05C以上の電流率で実施され、

放電は0.5C以上の電流率で実施され、

充電、あるいは放電時間がともに1秒以下であり、

充電、あるいは放電中に記録される端子電圧 V_2 は、充電、あるいは放電終了直前の電圧であり、

充電、あるいは放電終了後に記録される端子電圧 V_{oc3} は充電、あるいは放電終了後2秒以内の電圧であることを特徴とするアルカリ蓄電池容量残量推定法。

【請求項5】 データを管理するコンピュータと、アルカリ蓄電池の試験条件をコントロールする充放電器とから構成され、請求項2記載のアルカリ蓄電池容量残量推定法における適用基準式および電圧-容量曲線を演算する回路または機能を該コンピュータに内蔵して請求項2記載のアルカリ蓄電池容量残量推定法の手順に従って試験対象セル、または組電池の容量および残量推定を行うことを特徴とするアルカリ蓄電池容量推定装置。

【請求項6】 試験データを収集管理し、かつ、請求項2記載のアルカリ蓄電池容量残量推定法に従って容量および残量推定値を求めるために演算を行うコンピュータと、該試験セル、あるいは組電池の試験放電、あるいは充電条件を制御する電流制御器、または充放電制御器とから構成されるか、

または、既設コンピュータに請求項2記載のアルカリ蓄電池容量残量推定法の手順を行う演算回路、または機能とを増設して搭載してなり、かつ、該電流制御器、または充放電制御器とから構成されることを特徴とするアルカリ蓄電池容量推定装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、使用中のバックアップ用アルカリ蓄電池の容量および残量を予測するためのアルカリ蓄電池容量残量推定法および容量推定装置に関するものである。

【0002】なお、容量とは満充電状態から想定終止電圧に至るまで放電した場合の容量、残量とはある範囲まで放電した状態において規定終止電圧まであとどれくらい放電が可能かを示す容量の値を指している。容量は一定電流で放電した場合、電流×時間で求める。

【0003】

【従来の技術】近年、通信サービスの多様化、大規模化が進行し、同時に高信頼性も要求されている。これに伴って多種多様な無停電給電システムの導入、あるいはバックアップ電源の適用が推進され、バックアップ用二次電池も大量に使用されるようになってきた。これらの装置、システムの信頼性確保のために、バックアップ用二次電池の残量表示、保守、適切な取り替え時期の把握が

必要となってきた。

【0004】従来の二次電池容量推定方法としては、試験電池を、端子電圧が規定の放電終止電圧に到達するまで定電流放電しその時間を求める方法がある。

【0005】この方法では、電池の容量は正確に求めることができるが、長時間の測定となり、また、測定中に停電などのトラブルが生じると負荷装置への給電が不可能となるという欠点があった。

【0006】別の方法としては、交流インピーダンスによる内部インピーダンスを測定したり、あるいは一定時間の定電流放電、または充電を行い、これに対する電圧応答を電流値で除した値を内部抵抗として用いて、あらかじめ取得しておいた内部抵抗、あるいはインピーダンスと電池容量との関係に適用し、電池容量を推定する。

【0007】この方法では、比較的短時間で容量推定が可能となるが、あらかじめ試験対象となる各サイズ、各メーカー製電池の容量と内部インピーダンスとの関係を把握し、これを記憶しておく必要があり、膨大なデータ取得と記憶容量の確保が必要であった。さらには電池の改良ごとに新たなデータ取得と記録を実施する必要があるという欠点を有していた。

【0008】さらに、これらの方法による欠点を改善するために、係数補正のみで多種の電池に適用可能な汎用性の高い劣化判定基準式が考案された(特願平7-238363)。同方法では、短時間の放電、あるいは充電によって比較的簡単に容量推定が可能となる反面、判定のためには常に試験対象電池をあらかじめ満充電しておかなければならないという欠点を有していた。

【0009】また、これらのバックアップ電池については容量推定法のみ提案されており、充電と放電とを頻繁に繰り返して使用するサイクル用電池に関するような残量推定は皆無であった。そのため、バックアップ電池の劣化状態が正しく把握されていないと、予想していた使用時間に満たないという不便も生じることがしばしば存在した。

【0010】

【発明が解決しようとする課題】本発明の目的は、上記現状を解決するため、任意の放電状態で短時間に容量推定が実施でき、同時に残量もまた推定できるアルカリ蓄電池容量残量推定法および容量推定装置を提供することにある。

【0011】

【課題を解決するための手段】上記目的を達成するために本発明は、アルカリ蓄電池(以下、セルと呼称)、または直列に複数個接続されたアルカリ蓄電池群(以下、組電池と呼称)に関して、試験対象セル、あるいは組電池をいったん休止状態においた後、一定電流値で短時間放電、または充電して、その放電または充電前後の端子電圧の変化から内部抵抗を求め、この内部抵抗と休止状態における開回路電圧とを、容量と内部抵抗と開回路電

圧とからなる劣化判定基準式を試験対象の新品電池の内部抵抗と公称容量によって係数補正した判定式に適用して、満充電からの放電可能容量を推定すると同時に、放電、あるいは充電前後の休止状態における開回路電圧と該公称容量と推定容量とを、電圧-容量曲線に適用して残量を推定するアルカリ蓄電池容量残量推定法と、データを管理するコンピュータと、蓄電池の試験条件をコントロールする充放電器とから構成され、該試験電池の容量および残量推定法における劣化判定式と電圧-容量関係式を演算する回路または機能を該コンピュータに内蔵して上記に記載する手順に従って試験セル、または組電池の容量および残量推定を行うことを特徴とする装置と、既存の無停電給電システムや二次電池充放電自動試験装置に組み込み、試験電池の容量および残量推定を行うための、試験データを収集管理し、かつ、上記に記載する電池容量および残量推定法に従って容量および残量推定値を求めるために演算を行うコンピュータと、必要ならば、該試験電池の試験条件を制御する電流制御器、または充放電制御器とから構成されるか、または、既設コンピュータに上記に記載した電池容量および残量推定法の手順を行う演算回路、または機能を増設し搭載してなり、必要ならば、該電流制御器、または充放電制御器とから構成される容量および残量推定機能を提案するものである。

【0012】本発明になる電池容量および残量推定法が高い精度で推定可能な理由は、電池劣化の進行によってセパレータ中の電解液の減少、正極、負極抵抗の増大、負極かつ物質の減少によって電池の内部抵抗が増大すること、また、放電の進行によって例えば負極カドミウムが水酸化カドミウムに変化し、電解液濃度が変化するが、これら劣化、放電深度が内部抵抗と密接に関係しているため、端子電圧、内部抵抗、容量の因子で構成される推定法の基準式および電圧-容量曲線が電池の特性をより正確に表現できているためと考えられる。

【0013】なお、放電深度とは満充電状態から規定終止電圧までの完全放電状態に至るまで放電した場合を100%として、放電量の大きさ(放電の進み具合)を示すものである。Depth of DischargeからDODとも呼ばれる。記述としては定格容量に対する放電電気量の比率(%)である。逆に充電の進み具合を表す言葉は特になくSOC(State of Ch

$$Q = a \ln(Z) + b \quad (a, b \text{ は定数、} a < 0)$$

を基本的関係式として用いる。該基準式(1)については、満充電状態におけるニッケルカドミウム電池の内部抵抗Zの対数値と放電可能容量Qとが直線関係にあることを基本としている(N. Kato, et al., J. Power Source, (1997))。この結果をもとにさらに検討を進めた結果、満充電からの放電可能容量が公称容量の70%を超えるような比較的劣化の進行していない電池には任意の放電深度にある電池にも

arge) がしばしば使用される。

【0014】

【発明の実施の形態】以下図面を参照して本発明の実施の形態例を詳細に説明する。

【0015】アルカリ蓄電池(以下、セルと呼称)、または直列に複数個接続されたアルカリ蓄電池群(以下、組電池と呼称)に関して、該セル、あるいは組電池の端子電圧をモニタしながらこれをいったん休止状態に置き、端子電圧Voc1を記録した後、一定の電流値Iで短時間放電、あるいは充電を行い、その放電、充電直後の端子電圧V2を記録してその電圧差

$$\Delta V = Voc1 - V2$$

を放電、あるいは充電電流値で除した値Z

$$Z = \Delta V / I$$

を内部抵抗として求め、あるいは、一定の電流値Iで短時間放電、あるいは充電を行い、その放電、充電が終了し休止に入った直後の端子電圧Voc3を記録してその電圧差

$$\Delta V' = V2 - Voc3$$

を放電、あるいは充電電流値で除した値Z'

$$Z' = \Delta V' / I$$

を内部抵抗として求め、あらかじめ異なる劣化状態のセル特性から求めておいた劣化判定基準式の数値補正を実施してこれに適用して、該試験対象セル、あるいは組電池の満充電状態からの放電可能容量Qを推定すると同時に、上記の短時間充電、あるいは放電を実施する前の休止時の端子電圧Voc1、あるいは実施直後の休止時の端子電圧Voc3を、あらかじめ求めておいた該試験対象の新品セルの電圧-容量曲線に適用して算出した残量(放電残時間)Qr0と上記短時間充電、あるいは放電によって推定された満充電状態からの放電可能容量Qと該試験対象セル、あるいは組電池の公称容量Qoとから、残量(放電残時間)Qrを

$$Qr = Qr0 (Q / Qo)$$

によって推定する。

【0016】本発明をさらに詳しく説明する。

【0017】本発明になる電池容量および残量推定法において、満充電状態からの放電可能容量を推定する方法には電池容量Qと内部抵抗Zとから構成される劣化判定基準式

$$(1)$$

適用可能なことが判明した。その根拠を図1によって示す。

【0018】すなわち図1は、一定電流値にて一定時間放電するごとに測定した電圧応答ΔVの大きさを示した結果の一例を示した図であり、1-1は公称容量比100%の容量を持つ未劣化電池の各放電状態における電圧応答ΔVの大きさを示した曲線であり、1-2は同90%の場合の曲線であり、1-3は同80%の場合の曲線

であり、1-4は同70%の場合の曲線であり、1-5は同60%の場合の曲線である。

【0019】図1から明らかなように、公称容量比が80%以上の容量を持つ電池では、電圧応答の大きさ ΔV は放電状態によらずほぼ一定であることがわかる。

【0020】従って、本発明において使用される上記劣化判定基準式(1)は、従来の満充電状態の電池に関わる内部抵抗 Z と容量 Q との関係とはまったく異なった意

$$Q = a (Q_A / Q_B) \ln(Z) + Q_A - a (Q_A / Q_B) \ln(Z_A) \quad (2)$$

(Q_B は基準式作成のために用いたセルの容量)

となる劣化判定式として、満充電状態からの放電可能容量の推定に用いられる。

【0022】なお、上記劣化判定式(2)の導出は以下の通りで行った。

【0023】上記劣化判定基準式(1)を作成するのに

$$Q_B = a \ln(Z_B) + b \quad (21)$$

$$Q_B / n = a \ln(Z_B) + [a \ln(p) + b] \quad (22)$$

が成り立つ。

Z の関係は

【0024】ここで、試験対象電池の容量 Q と内部抵抗

$$Q = a^* \ln(Z) + b^* \quad (a^*, b^* \text{ は定数、} a^* < 0) \quad (23)$$

が成り立っているとする。

【0025】式(13)を構成する試験対象電池Aの容量を Q_A 、内部抵抗 Z_A とし同じく同式(1)を作成す

$$Q_A = a^* \ln(Z_A) + b^* \quad (24)$$

$$Q_A / m = a^* \ln(Z_A) + [a^* \ln(p) + b^*] \quad (25)$$

となる。

【0026】

式(11)-式(12)から

$$Q_B [1 - (1/n)] = -a \ln(p) \quad (26)$$

式(14)-式(15)から

$$Q_A [1 - (1/m)] = -a^* \ln(p) \quad (27)$$

式(16)/式(17)より

$$(Q_B / Q_A) [(1 - 1/n) / (1 - 1/m)] = a / a^* \quad (28)$$

$n \gg 1, m \gg 1$ だから式(18)から

$$a^* = a (Q_A / Q_B) \quad (29)$$

式(19)を式(14)に代入して

$$b^* = Q_A - a (Q_A / Q_B) \ln(Z_A) \quad (30)$$

式(19)、式(20)を式(13)に代入して上記劣化判定式(2)を得ることができる。

【0027】しかしながら、上記劣化判定式(2)は劣化状態の進行が進むと満充電状態の場合しか適用できなくなる。それは先に示した図1によって明らかである。

【0028】すなわち、図1において、劣化が進行した公称容量比70%、および60%の容量の電池では、放電が進むにつれて、電圧応答の大きさ ΔV が大きくなっ

$$Q = Q_A \{ [\ln(Z) + dV - e] / (fV - g) \} \quad (3)$$

(d, e, f, g は定数)

を本発明では提案するものである。

【0030】上記劣化判定式(3)は図1におけるような各放電深度での電圧応答の大きさ ΔV の結果を基本に

味を持ち、適用領域が異なっていることがわかる。すなわち、満充電状態を含めた任意の放電状態における内部抵抗が上記劣化判定基準式(1)に適用可能であることになる。

【0021】上記劣化判定基準式(1)は、係数 a, b を試験対象セル、あるいは組電池の公称容量 Q_A と内部抵抗 Z_A とによって変換され、

用いた電池Bの容量を Q_B とし、同じく同式(1)を作成するのに用いた大幅に劣化した電池の容量は電池Aの容量の $1/n$ であり、内部抵抗は電池Aの p 倍であるとする、

るのに用いた電池は、内部抵抗が電池Aの p 倍である大幅に劣化電池で、その容量は電池Aの容量の $1/m$ であるとする、

てくる。特に、開回路電圧 V_{oc} が1.20V以下になると ΔV の増大は顕著であり、このままでは放電深度が深い状態の試験セル、あるいは組電池には劣化判定式(2)が適用不可能である。

【0029】そこで上記判定式(2)に代わる劣化判定式として、内部抵抗 Z と開回路電圧 V とで表される容量 Q の式、

して作成された関係式である。該判定式(3)における定数 d, e, f, g は、試験対象セル、あるいは組電池に該当する未劣化品について、異なる4段階の放電深度

まで放電させて求めた開回路電圧と内部抵抗の値と、公称容量から求めた容量 Q_A から $Q=Q_A$ として(3)式に適用し、これらを決定して用いる。

【0031】以下に上記劣化判定式(3)の導出手順を概説する。

【0032】電圧応答 ΔV の対数と開回路電圧 V との関係を図2に示す。図2に明らかなように、電圧応答 ΔV の対数値と開回路電圧 V との間には、極めて良い直線関係が得られる。

$$\ln(Z) = -jV + k$$

(31)式において、係数 j および k は電池の劣化度、すなわち Q/Q_A (Q_A は公称容量)に直線的に依存

$$j = -f(Q/Q_A) + d$$

および

$$k = -g(Q/Q_A) + e$$

となる。(32)、(33)を(31)に代入すると、

$$\ln(Z) = -[-f(Q/Q_A) + d]V + [-g(Q/Q_A) + e]$$

$$(34)$$

$$\ln(Z) = (fV - g)(Q/Q_A) - dV + e$$

$$(35)$$

(35)式より上記劣化判定式(3)が求まる。

【0036】該判定式(3)に、開回路電圧 V_{oc1} 、または V_{oc3} と、内部抵抗 Z 、または Z' とを代入して算出した値 Q を、満充電状態からの放電可能容量とする。

【0037】劣化判定式(3)を式(2)の代わりに適用する条件は、試験対象セル、あるいは組電池の開回路電圧 V_{oc1} 、または V_{oc3} と、劣化判定式(2)を用いて推定した満充電状態からの放電可能容量 Q と、該当する未劣化品の容量 Q_A との関係が実験データから判断して

$$V_{oc1}(Q/Q_A) < 0.85 \times (\text{セル数})$$

または、

$$V_{oc3}(Q/Q_A) < 0.85 \times (\text{セル数})$$

となる場合である。上記比が $0.85 \times (\text{セル数})$ 以上の場合に劣化判定式(3)を用いると、劣化判定式(2)より推定値の誤差が大きくなってしまう場合があり好ましくない。

【0038】本発明になる方法では、このようにして満充電状態からの放電可能容量 Q を求めることが可能となるとともに、同時に、試験時の放電状態から後どの程度放電が可能かという残量も判定が可能である。

【0039】すなわち、上記の短時間充電、あるいは放電を実施する前の休止時の端子電圧 V_{oc1} 、あるいは実施直後の休止時の端子電圧 V_{oc3} を、あらかじめ求めておいた該試験対象の新品セルの電圧-容量曲線に適用して算出した残量(放電残時間) Q_{r0} と上記短時間充電、あるいは放電によって推定された満充電状態からの放電可能容量 Q と該試験対象セル、あるいは組電池の未劣化品の容量 Q_A とから、残量(放電残時間) Q_r を
 $Q_r = Q_{r0}(Q/Q_A)$

【0033】図2において、2-1は公称容量比100%の容量を持つ未劣化電池の開回路電圧 V と電圧応答 ΔV の関係を示した直線であり、2-2は同90%の場合の直線であり、2-3は同80%の場合の直線であり、2-4は同70%の場合の直線であり、2-5は同60%の場合の直線である。

【0034】従って、内部抵抗 Z と開回路電圧 V との間には以下の関係式が成立する。

【0035】

$$(31)$$

し、

$$(32)$$

$$(33)$$

によって推定する残量を推定するために使用する電圧-容量曲線は、試験対象の満充電状態におかれた新品セルの開回路端子電圧 V_o を記録した後これを、0.1C、ないし0.2Cの電流率で30分以下の一定時間で放電し、これを1時間以上の休止状態におき休止時の最後に開回路端子電圧 V_{ox} を記録して、再び同一条件で放電させ、これを1.0V以下の電圧まで繰り返して V_o と V_{ox} とを、放電時間(放電容量)ごとにプロットして求める。

【0040】なお、Cは、放電や充電の電流値の大きさを示す1つの値である。時間率という考え方があり、電流 I で終止電圧になるまで放電するのにも時間かかる場合、 t 時間率放電という言い方で電流値を表す。その時、電池の定格容量(公称容量)をCとして用いる。例えば、1Cという場合、1時間で放電を終了する1時間率放電を示す。定格容量が1Ahの電池の場合、 $1 \times 2 = 2A$ の電流値で放電したことになる。0.2Cと例えば、 $0.2 \times 2 = 0.4A$ の電流値で放電し、これは0.4時間率放電(放電に5時間かかる)になる。Cに公称容量の値を適用して、その前の数値をかけ算すれば電流値が求まる。

【0041】上記電圧-容量曲線を求めるための放電条件は、0.2C以下0.1C以上であればこれに限定されることはないが、算出上0.1C、0.2Cが簡便であり好ましい。0.1C未満の放電では、該曲線を求めるために膨大な時間を要し、かつ試験中に電池の状態が放電以外の要素(特に自己放電)で変化してしまう可能性があり好ましくない。また、0.2Cを越える大きな電流率では、放電後の休止状態が不安定であり、電圧の誤差が大きくなり好ましくない。

【0042】さらに放電時間を30分より長くすると、

データ数の減少につながって、基準となる電圧-容量曲線の信頼性の低下をきたすことになり好ましくない。休止時間については1時間未満だと安定な休止状態に至らず電圧の誤差が大きくなり好ましくない。

【0043】本発明になる電池容量および残量推定法では、試験対象となるアルカリ蓄電池（セル）、または直列に接続された複数の組電池をいったん休止状態においた後、一定電流値で短時間放電してその端子電圧の変化を測定する。

【0044】推定のために必要な充電、放電時間は1秒以下であることが好ましい。充電、または放電時間が1秒を超える長い時間では、端子電圧の変化に電池の内部抵抗だけでなく電解液中のイオンの拡散の遅れによる影響が強く含まれるようになり、この影響が判定誤差を大きくするので好ましくない。

【0045】推定のために1秒以下の短時間充電を実施する場合、電流値は0.05C以上の電流率であることが好ましい。0.05Cより小さい電流率の充電電流では電圧変化が小さく端子電圧の読み取り誤差が大きくなって推定誤差の増大を招くことになり好ましくない。

【0046】同様に、推定のために1秒以下の短時間放電を実施する場合、電流値は0.5C以上の電流率であることが好ましい。0.5Cより小さい電流率の放電電流では電圧変化が小さく端子電圧の読み取り誤差が大きくなって推定誤差の増大を招くことになり好ましくない。

【0047】充電、あるいは放電前の端子電圧 V_{oc1} は試験対象セル、あるいは組電池が休止状態におかれ充電、あるいは放電が開始される2秒以内の電圧であることが好ましい。充電、あるいは放電開始の2秒を超える以前の端子電圧では、試験電池の状態が変化し、充電、放電を実施した電池状態との関係が複雑となり好ましくない。

【0048】また、充電、あるいは放電終了後に記録される端子電圧 V_{oc3} は充電、あるいは放電終了後2秒以内の電圧であることが好ましい。2秒を超えた後の端子電圧では、試験電池内部の状態が大きく変化してしまい、 V_{oc1} や V_2 との関係が複雑となって誤差の増大をきたすので好ましくない。

【0049】本発明になる電池容量および残量推定方法を適用して満充電状態からの放電可能容量および残量推定を行う装置は、データを管理するコンピュータと、電池の試験条件をコントロールする充放電器とから構成され、該電池容量および残量推定方法における劣化判定式、および電圧-容量曲線（関係式）をもとに演算する回路または機能を該コンピュータに内蔵して上記に記載する手順に従って試験セル、または組電池の容量および残量推定を行うことを特徴とする。

【0050】該容量および残量推定装置の構成概念の一例を図3に示すが、試験制御、データ収集、電池容量お

よび残量推定の実行機能が満足されれば、構成は何らこれに限定されるものではない。

【0051】図3は1の試験対象セル、あるいは組電池を、12の試験装置に配置した概念の一例を示したものである。試験装置12は、該試験電池1を試験するために具体的な充電、放電の実行を行う充放電器2と、この充放電器の制御や記憶、記録を行うコンピュータ3で構成される。

【0052】充放電器2は、定電流負荷装置4と定電流定電圧電源5、およびスイッチS1、S2とから構成されている。定電流負荷装置4は、試験電池1から供給される電流が一定の設定値に維持されるように負荷を変動させるものである。定電流定電圧電源5は充電、放電が一定の時間で規定されている場合に設定電圧に達するまでの間、定電流源として動作し、設定電圧に達した後は定電圧電源として動作する。

【0053】コンピュータ3は、試験全体を制御するCPU6、充放電制御とデータ記録、さらには本発明の電池容量および残量推定法に関する劣化判定基準式や電圧-容量関係式（曲線）のプログラムがあらかじめ収納されているROM7の他、さらに該基準式から上記に記載した手順によって判定式を作成し、この劣化判定式と電圧-容量関係式に試験データを適用して容量および残量推定を行う作業用RAM8、およびプリンタ9、キーボード10、充放電状態や試験結果を表示する表示器11から構成される。

【0054】ROM7に格納されているプログラムに従って、CPU6が充放電器2の定電流定電圧電源5、定電流負荷装置4、スイッチS1、S2、の装置全体を制御する。個々の特性試験に必要な設定値などはキーボード10によって入力される。

【0055】コンピュータ3においては、あらかじめ設定された条件において試験の制御を行いながら、試験電池1の端子電圧、電流、さらに必要に応じて温度、湿度、電池歪みなどのデータを所定の時間間隔で測定し、記憶し、さらに記録する。また、得られた試験データに基準式を適用し、判定式を作成して試験対象セル、あるいは組電池の満充電状態からの放電可能容量を推定し、電圧-容量関係式に適用して残量推定を行う演算機能、さらに必要ならば試験データを一定時間毎にプロットする特性作成機能を具備している。

【0056】本発明になるアルカリ蓄電池の容量および残量推定機能は、試験データを収集管理し、かつ、上記の手順に従って容量および残量推定値を求めるために演算を行うコンピュータと、必要ならば、該試験電池の試験放電条件を制御する放電電流制御器、または充放電制御器とから構成されるか、または、既設コンピュータに上記に記載した電池容量および残量推定法の手順を行う演算回路、または機能とを増設し搭載してなり、必要ならば、放電電流制御器、または充放電制御器とから構成

され、既存の無停電給電システムや二次電池充放電自動試験装置に組み込んで、従来の機能を加えて試験対象電池の容量および残量推定を可能にする機能を付与することを特徴とするものである。

【0057】従って、本発明になる該試験電池容量および残量推定機能は、できるだけ、既存装置、あるいはシステム本来の機能を損なったり、低下させないことで、容量および残量推定を行う。

【0058】一例として無停電給電システムに本発明になる電池容量および残量推定機能を付与した構成概念を図4に示す。

【0059】図4は本発明になる電池容量および残量推定機能のコンピュータ制御部を電力変換装置の内部に配置し、接続して構成された無停電給電システムの構成概念の一例を示したものである。

【0060】図4において、1の試験セル、あるいは組電池と、13の交流、または直流電源と、14の電力変換装置と、15の負荷装置とによって無停電給電システムの基本構成をなしている。14の電力変換装置内には、主変換回路16が搭載されて、電源13からの交流、または直流電力を変換する。

【0061】本発明における電池容量および残量推定機能は、コンピュータ3と定電流制御回路17と試験時に主回路から切り離すスイッチ18とで構成される。

【0062】本発明の容量および残量推定機能を構成するコンピュータ3は、容量および残量推定のための放電、あるいは充電試験全体を制御するCPU6、試験制御とデータ記録、さらには本発明の電池容量および残量推定法に関する基準式、および関係式のプログラムがあらかじめ収納されているROM7の他、さらに該基準式を上記に記載した手順によって試験データに適用し判定式を作成して容量推定を行い、電圧-容量関係式に適用して残量推定を行う作業用RAM8、およびプリンタ9、キーボード10、放電状態や試験結果を表示する表示器11から構成される。表示器11は、使用上の利便

$$Q = -1291 \times \ln(Z) + 8490 \quad (4)$$

となり、これを劣化判定基準式とした。

【0069】次に、試験対象となるトリクル単三ニッケルカドミウム電池の3セル直列パック（公称容量600mAh）の新品を購入し、電流値は充電を0.1CmA（60mA）、放電を0.2CmA（120mA）、内

$$\begin{aligned} Q &= a (Q_A / Q_B) \ln(Z) + Q_A - a (Q_A / Q_B) \ln(Z_A) \\ &= -174 \times \ln(Z) + 1368 \end{aligned} \quad (5)$$

なるトリクル単三ニッケルカドミウム電池の3セル直列パックの劣化判定式を得た。

【0070】上記試験を実施した後、該電池パックを0.1CmA（60mA）で16時間充電した後、1時間休止を置き端子電圧Voc1を測定してから、600mA、10msecの短時間放電を実施し、放電終了直前に端子電圧V2を測定し上記方法と同様にして内部抵抗

性を考慮して該コンピュータ3の他に、電力変換装置14の壁面の作業者の認識しやすい部位にも取り付けることができる。

【0063】なお、図4に示した構成概念はあくまで具体的な一例であって、上述した容量推定の機能を保持し、構成要素を完備していれば、無停電給電システム、あるいはそれ以外の装置に該容量推定機能を付与する構成は何らこれに限定されることはない。

【0064】以下に、本発明になる電池容量および残量推定方法について実施例によって説明するが、本発明は何らこれらに限定されるものではない。

【0065】

【実施例】[実施例1] 非常灯に用いられていたトリクル単一ニッケルカドミウム電池（公称容量 $Q_B = 4 \text{ Ah}$ ）を回収するとともに、同型の新品電池を購入して、内部抵抗と容量とを評価した。

【0066】実施した試験は、以下の通りである。

【0067】すなわち、回収、または購入した各電池を電池充放電試験装置に設置して、0.1CmA（400mA）の電流値で16時間充電し、1時間休止の後、0.2CmA（800mA）の電流値で1.0Vまで放電し、1時間の休止を行う。これを2回繰り返し、3回目の放電を開始する直前の休止状態で、1.0CmA（4000mA）の電流値で10msecの短時間放電を行い、その電圧応答の大きさを測定した。電圧応答は、短時間放電を実施する直前と、短時間放電を終了する直前の端子電圧の差を採用した。この短時間放電の後、1時間の休止を置いて、0.2CmA（800mA）の定電流で1.0Vまで放電を行い、この容量を電池容量とした。電圧応答の大きさを電流値で除した値を内部抵抗とした。

【0068】こうして測定した各電池の容量Qを内部抵抗Zの対数についてプロットすると良好な直線関係が得られ、その関係は

部抵抗を求めるための短時間放電を1.0CmA（600mA）とした以外上記と同様の条件で試験を行い容量 $Q_A = 642$ と内部抵抗 $Z_A = 65.25$ を求めた。これらの値をもとに、劣化判定基準式（4）の係数 $a = -1291$ と $b = 8490$ を補正して

$Z1 = (Voc1 - V2) / 600$ を求めた。その後、0.2CmA（120mA）で30分間（60mAh）放電してから、2時間の休止をおき、端子電圧Vocxを測定した後、再び600mA、10msecの短時間放電を実施し端子電圧Vx2を測定してこれを終了し、上記方法と同様にして内部抵抗 $Zx = (Vocx - Vx2) / 600$ を求めた。

【0071】この30分放電、2時間休止、端子電圧 V_{ocx} 測定、10msec放電、端子電圧 V_{x2} 測定の操作を放電時の電圧が3.0V(1.0V/セル)に至るまで繰り返した。放電電圧が3.0V(1.0V/セル)に至ると直ちに放電を終了し、2時間の休止ののち上記

$$Q = Q_A \{ [\ln(Z) + dV - e] / (fV - g) \} \quad (3)$$

(d, e, f, gは定数)

の定数d, e, f, gを算出し、

$$Q = 642 \times \{ [\ln(Z) + 15.1V - 11.3] / (0.15V - 0.208) \} \quad (6)$$

なる別の劣化判定式を作成した。該判定式(6)は、

$$V_{oc1} (Q/Q_A) < 2.55 (0.85V \times 3 \text{セル}) \quad (7)$$

となる場合に、上記劣化判定式(5)に代わって使用することにした。

【0073】また、上記試験によって求めた放電における端子電圧が3.0Vに至る各放電状態の休止電圧 V_{oc1} と満充電からの総放電量との関係、電圧-容量曲線をあらかじめプロットして、図5に示す残量算出のための

$$Q_{r0} = Q_A - Q_1$$

Q_{r0} を未劣化品の場合の残量とする。また、この残量を

$$100 \times (Q_{r0}/Q_A)$$

として、パーセントで示すこともできる。

【0075】こうして得られた劣化判定式(5)、および(6)、および電圧-容量の基礎データをもとに、回収したトリクル単一ニッケルカドミウム電池パック(3セル直列、公称容量600mAh)の容量および残量推定を行った。

【0076】回収した電池パックは、まず0.1CmA(60mA)で16時間充電し、1時間の休止を置く。端子電圧 V_{oc1} を測定した後、1.0CmA(600mA)で10msecの短時間放電を行い、放電終了直前の電圧 V_2 を測定し、内部抵抗 $Z = \Delta V / I = (V_{oc1} - V_2) / 600$ を求める。

【0077】該電池パックを2時間休止した後、0.2CmA(120mA)で開回路電圧 V_{oc1} が3.60V(1.20V/セル)以上3.75V(1.25V/セ

$$Err = 100 \times (Q - Q_m) / Q_m$$

を算出し、これを誤差Errとした。

【0081】結果を図6に示す。

【0082】図6は実測した満充電状態からの放電可能容量に対する、上記(10)の関係によって求めた誤差を示した図である。図6において、白丸は満充電状態での試験電池パックの測定結果であり、四角は端子電圧 V_{oc1} が3.60V以上3.75V未満の放電状態にある試験電池パックの測定結果であり、黒丸は端子電圧 V_{oc1} が3.30V以上3.60V未満の放電状態にある試験電池パックの測定結果である。

【0083】図6に明かなように、測定対象となった

$$Q_r = Q_{r0} (Q/Q_A)$$

によって試験電池の残量を推定した。これを上記に示し

$$Err(r) = 100 \times (Q_r - Q_{rm}) / Q_{rm}$$

と同じ条件で内部抵抗を求めた。

【0072】こうして求めた試験データのうち、4つの放電状態のデータを選択し、それぞれの短時間放電を実施する直前の休止電圧 V_{ocx} と、内部抵抗 Z_x と、上記 $Q_A = 642$ とから

基礎データを得た。

【0074】図5は、該試験電池パックの残量を推定するために使用される基礎データであり、一例として、試験した電池パックの端子電圧 V_{oc1} が図5に示した値である場合、その値を曲線に適用して満充電からの容量 Q_1 が求められ、初期容量 Q_A との差、

$$(8)$$

$$(9)$$

ル)未満となるまで放電する。1時間の休止後、上記と同様の手順で端子電圧 V_{oc1} 、内部抵抗 Z を測定する。

【0078】さらに2時間休止した後、0.2CmA(120mA)の電流値で開回路電圧 V_{oc1} が3.30V(1.10V/セル)以上3.60V(1.20V/セル)未満となるまで放電し、同様にして2時間休止の後、端子電圧 V_{oc1} と内部抵抗を測定する。

【0079】こうして測定した端子電圧 V_{oc1} と内部抵抗を関係式(7)を考慮して劣化判定式(5)または(6)に代入し、満充電からの放電可能容量 Q を算出した。

【0080】さらに、該試験電池パックは、0.2CmA(120mA)で端子電圧3.0V(1.0V/セル)まで放電し、満充電からの総容量を求め、これを実測容量 Q_m とした。推定容量 Q と実測容量 Q_m とから、

$$(10)$$

電池パックのあらゆる容量(劣化状態)に対し、本発明になる方法により推定した満充電からの放電可能容量は、実測した容量に比べて誤差±15%以内と良好な推定精度であることが判った。

【0084】さらに、端子電圧 V_{oc1} の値を図5に示す電圧-容量曲線(関係)に適用し、上記図5に示した電圧-容量の関係から(8)式によって得られた残量 Q_{r0} と、これに劣化判定式(5)および(6)によって得られた満充電からの放電可能推定容量 Q と初期容量 Q_A とから

$$(11)$$

た方法で測定した実測残量 Q_{rm} と比較し、

$$(12)$$

として誤差を求めた。

【0085】結果を図7に示す。図7は試験した異なる劣化状態にある3個の電池パックについて、実測残量に対する(12)式で求めた推定残量の誤差 $Err(r)$ の結果を示したものである。

【0086】図7に示したように、各放電状態で測定した推定残量は、実測値に比べて±10%以内の誤差であり、本発明になる方法により、高精度で残量が推定可能であることが判った。

$$J = Voc1 (Q / Q_A)$$

の値を変えて判定誤差の大きさを調べた。

【0089】結果を図8に示す。

【0090】図8は、上記実施例1に示した劣化判定式(6)を使用する判断基準である、式(13)によって求めた値Jに対する誤差範囲を示したものである。

【0091】図8から明らかなように、Jの値が2.55未満で劣化判定式(6)を使用した場合の推定容量の実測容量に対する誤差は、Jの値が2.55以上で同(6)式を使用した場合に比べて小さくなり良好な精度で容量推定が可能になることがわかった。

【0092】[実施例3]トリクル単三ニッケルカドミウムセル(公称容量600mAh)の残量を推定するために、電圧-容量曲線を作成した。

【0093】試験対象の未劣化品10セルについて、これをいったん0.1CmA(60mA)で16時間充電した後、開回路端子電圧 V_{oc} を記録し、これを図11に示す条件で放電し、休止状態におき、休止時の最後に開回路端子電圧 V_{ocx} を記録して、再び同一条件で放電させ、これを1.0V以下の電圧まで繰り返して V_{oc} と V_{ocx} とを、放電時間(放電容量)ごとにプロットした。

【0094】トリクル単三ニッケルカドミウムセル(公称容量600mAh)を100セル回収し、0.1CmA(60mA)の電流率で16時間充電した後、実施例1と同様にして満充電状態からの放電可能容量を推定するとともに、実施例1と同様にして、開回路端子電圧 V_{oc1} と推定容量Qをそれぞれの未劣化品セルについて作成した上記電圧-容量曲線に各10セルずつ適用して残量 Q_r を推定するとともに、実測残量 Q_{rm} も併せて求めた。(12)式によって推定誤差を算出し、その絶対値

$$a' = a (Q_A / Q_B) \quad (14)$$

$$b' = Q_A - a (Q_A / Q_B) \ln(Z_A) \quad (15)$$

その後、該電池パックを0.1CmA(60mA)の電流率で16時間充電し、1時間休止した。続いて、端子電圧 V_{oc1} を測定し、電流率1.0CmA(600mA)で、図12に示した時間tだけ短時間放電し、該放電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.2CmA(120mA)の電流率で30分間放電し、2時間の休止をおいた。2時間休止が完了すると端子電圧を測定し放電深度xにおける開回路電圧 V_{ocx} とした。そして再び同条件の短時間放電を

【0087】[実施例2]実施例1において試験した電池パックの結果を用い、各放電状態での端子電圧 V_{oc1} と実施例1における劣化判定式(5)および(6)から求めた、満充電からの放電可能容量推定Qの判定精度の検討を実施した。

【0088】劣化判定式(6)の使用基準となる、試験電池パックの端子電圧 V_{oc1} と未劣化品の容量 Q_A と劣化判定式(5)から求めた推定容量Qとの関係、

$$(13)$$

の最大値を図11に示した。

【0095】図11に示した絶対誤差の最大値から明らかなように、電圧-容量曲線を作成する放電の条件は、0.1CmA(60mA)、0.2CmA(120mA)の電流率、各放電の時間は0.5時間以下が好ましく、また各放電後の休止時間は1時間以上であることが好ましいことがわかった。

【0096】[実施例4]実施例1に用いたのと同様の5つのトリクル単三ニッケルカドミウム電池パック(3セル直列)新品を購入し、上記実施例1において求めた劣化判定基準式(4)から劣化判定式を導いた。

【0097】すなわち、該電池パックを0.1CmA(60mA)の電流率で16時間充電し、1時間休止した後、0.2CmA(120mA)の電流率で3.0V(1.0V/セル)まで放電し、1時間休止を行う。この充放電を2回繰り返す、さらに、同じ条件で充電し休止した。放電を実施する前に、端子電圧 V_{oc1} を測定し、電流値1.0CmA(600mA)で、図12に示した時間tだけ短時間放電し、該放電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.2CmA(120mA)の電流率で3.0Vまで放電を行い、この放電から容量 Q_A を求めた。内部抵抗 Z_A は $Z_A = (V_{oc1} - V_2) / 600$ から求めた。これらの値をもとに、劣化判定基準式(4)の係数 $a = -1.291$ と $b = 8490$ を補正して劣化判定式(2)の係数 a' 、 b' を以下の式で決定、図12に示す値を得た。

【0098】

実施、端子電圧 V_{x2} を測定して短時間放電を終了した

【0099】放電中の端子電圧が3.0V(1.0V/セル)に到達するまで、この30分間放電、2時間休止、端子電圧 V_{ocx} 測定、短時間放電、端子電圧 V_{x2} 測定の手順を繰り返した。これらの各放電深度xにおける V_{ocx} と $Z_x = (V_{ocx} - V_{x2}) / I$ と容量 Q_A から別の劣化判定式(3)の係数d, e, f, gを決定、図12に示す値を得た。

【0100】このようにして作成した2つの劣化判定式

に基づいて、回収したトリクル単三ニッケルカドミウム電池パック（3セル直列、公称容量600mAh）50パックについて各10パックずつそれぞれの未劣化品から作成した判定式に適用し、実施例1と同様にして容量推定と実際の容量測定を行った。

【0101】図12に結果を示す。すなわち、図12には、測定した推定容量 Q と実測容量 Q_m とから得られた誤差の絶対値の最大を示しており、短時間放電時間 t が1秒以下では誤差が小さく高精度の容量推定を行えることが明らかとなった。

【0102】[実施例5] 実施例1に用いたのと同様の5つのトリクル単三ニッケルカドミウム電池パック（3セル直列）新品を購入し、上記実施例1において求めた劣化判定基準式（4）から劣化判定式を導いた。

【0103】すなわち、該電池パックを0.1CmA

$$a' = a (Q_A / Q_B) \quad (14)$$

$$b' = Q_A - a (Q_A / Q_B) \ln (Z_A) \quad (15)$$

その後、該電池パックを0.1CmA（60mA）の電流率で16時間充電し、1時間休止した。続いて、端子電圧 V_{oc1} を測定し、図13に示す各電流率で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.2CmA（120mA）の電流率で30分間放電し、2時間の休止をおいた。2時間休止が完了すると端子電圧を測定し放電深度 x における開回路電圧 V_{ocx} とした。そして再び10msec短時間放電を実施、端子電圧 V_{x2} を測定して短時間放電を終了した。

【0105】放電中の端子電圧が、3.0Vに到達するまで、この30分間放電、2時間休止、端子電圧 V_{ocx} 測定、10msec短時間放電、端子電圧 V_{x2} 測定を繰り返した。これらの各放電深度 x における V_{ocx} と $Zx = (V_{ocx} - V_{x2}) / I$ と容量 Q_A から別の劣化判定式（3）の係数 d 、 e 、 f 、 g を決定、図13に示す値を得た。

【0106】このようにして作成した2つの劣化判定式に基づいて、図3に示す、本発明になる容量および残量判定機能を具備した充放電試験装置を使用して、回収したトリクル単三ニッケルカドミウム電池パック（3セル直列、公称容量600mAh）50パックについて実施例1と同様にして各未劣化品から作成した劣化判定式に10パックずつ適用し、容量推定と実際の容量測定を行った。

$$a' = a (Q_A / Q_B) \quad (14)$$

$$b' = Q_A - a (Q_A / Q_B) \ln (Z_A) \quad (15)$$

その後、該電池パックの端子電圧 V_{oc1} を測定し、図14に示す各電流率で、10msecの間短時間充電し、該充電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.1CmA（60mA）の電流率で1時間充電し、1時間の休止した。1時間休止が完了すると端子電圧を測定し充電状態 X における開回路電

（60mA）の電流率で16時間充電し、1時間休止した後、0.2CmA（120mA）の電流率で3.0V（1.0V/セル）まで放電し、1時間休止を行う。この充放電を2回繰り返し、さらに、同じ条件で充電し休止した。放電を実施する前に、端子電圧 V_{oc1} を測定し、図13に示す各電流値 I で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.2CmA（120mA）の電流率で3.0Vまで放電を行い、この放電から容量 Q_A を求めた。内部抵抗 Z_A は $Z_A = (V_{oc1} - V_2) / I$ から求めた。これらの値をもとに、劣化判定基準式（4）の係数 $a = -1291$ と $b = 8490$ を補正して劣化判定式（2）の係数 a' 、 b' を以下の式で決定、図13に示す値を得た。

【0104】

$$(14)$$

$$(15)$$

【0107】図13に結果を示す。すなわち、図13には、測定した推定容量 Q と実測容量 Q_m とから得られた誤差の絶対値の最大を示しており、10msec短時間放電の電流値が0.5CmA以上では誤差が小さく高精度の容量推定を行えることが明らかとなった。

【0108】[実施例6] 実施例1に用いたのと同様の5つのトリクル単三ニッケルカドミウム電池パック（3セル直列）新品を購入し、上記実施例1において求めた劣化判定基準式（4）から劣化判定式を導いた。

【0109】すなわち、該電池パックを0.1CmA（60mA）の電流率で16時間充電し、1時間休止した後、0.2CmA（120mA）の電流率で3.0Vまで放電し、1時間休止を行う。この充放電を2回繰り返し、さらに、同じ条件で充電し休止した。放電を実施する前に、端子電圧 V_{oc1} を測定し、図14に示す各電流値 I で、10msecの間短時間充電し、該充電を終了する直前の端子電圧 V_2 を測定した。1時間の休止をおいた後、0.2CmA（120mA）の電流率で3.0Vまで放電を行い、この放電から容量 Q_A を求めた。内部抵抗 Z_A は $Z_A = (V_2 - V_{oc1}) / I$ から求めた。これらの値をもとに、劣化判定基準式（4）の係数 $a = -1291$ と $b = 8490$ を補正して劣化判定式（2）の係数 a' 、 b' を以下の式で決定、図14に示す値を得た。

【0110】

$$(14)$$

$$(15)$$

圧 V_{ocx} とした。そして再び10msec短時間放電を実施、端子電圧 V_{x2} を測定して短時間放電を終了した。

【0111】充電の総時間が16時間に到達するまで、この1時間放電、1時間休止、端子電圧 V_{ocx} 測定、10msec短時間充電、端子電圧 V_{x2} 測定を繰り返した。これらの各充電状態 X における V_{ocx} と $Zx = (V$

$x2 - Vocx$) / I と容量 Q_A から別の劣化判定式 (3) の係数 d, e, f, g を決定、図14に示す値を得た。

【0112】このようにして作成した2つの劣化判定式を適用した、図3に示す、本発明になる容量および残量判定機能を具備した充放電試験装置を使用して、回収したトリクル単三ニッケルカドミウム電池パック (3セル直列、公称容量600mAh) 50パックを各10パックずつ適用して、実施例1に示した短時間放電の代わりに、電流率が図14に示す値で短時間充電を行う以外は実施例1と同様の手順で容量推定と実際の容量測定を行った。

【0113】図14に結果を示す。すなわち、図14には、測定した推定容量 Q と実測容量 Q_m とから得られた誤差の絶対値の最大を示しており、10msec短時間放電の電流値が0.05CmA以上では誤差が小さく高精度の容量推定を行えることが明らかとなった。

【0114】[実施例7] 実施例1に用いたのと同様の5つのトリクル単三ニッケルカドミウム電池パック (3セル直列) 新品を購入し、上記実施例1において求めた劣化判定基準式 (4) から劣化判定式を導いた。

【0115】すなわち、該電池パックを0.1CmA (60mA) の電流率で16時間充電し、1時間休止した後、0.2CmA (120mA) の電流率で3.0Vまで放電し、1時間休止を行う。この充放電を2回繰り返す、さらに、同じ条件で充電し休止した。放電開始2秒前に、端子電圧 $Voc1$ を測定し、1.0CmA (600mA) の電流率で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 $V2$ を測定した。1時間の休止をおいた後、0.2CmA (120mA) の電流率で3.0Vまで放電を行い、この放電から容量 Q_A を求めた。内部抵抗 Z_A は $Z_A = (V2 - Voc1) / I$ から求めた。これらの値をもとに、劣化判定基準式 (4) の係数 $a = -1291$ と $b = 8490$ を補正して劣化判定式 (2) の係数 a', b' を以下の式で決定、下記に示す値を得た。

【0116】 $-174 = a (Q_A / Q_B)$

$1368 = Q_A - a (Q_A / Q_B) \ln (Z_A)$

その後、該電池パックを0.1CmA (60mA) の電流率で16時間充電し、1時間休止した。続いて、放電開始2秒前に、端子電圧 $Voc1$ を測定し、1.0CmA (600mA) の電流率で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 $V2$ を測定した。1時間の休止をおいた後、0.2CmA (120mA) の電流率で30分間放電し、2時間の休止をおいた。2時間休止が完了すると次の放電開始2秒前に、端子電圧を測定し放電深度 x における開回路電圧 $Vocx$ とした。そして再び10msec短時間放電を実施、端子電圧 $Vx2$ を測定して短時間放電を終了した。

【0117】放電中の端子電圧が3.0Vに到達するまで、この30分間放電、2時間休止、端子電圧 $Vocx$ 測

定、10msec短時間放電、端子電圧 $Vx2$ 測定を繰り返した。これらの各放電深度 x における $Vocx$ と $Z_A - (Vocx - Vx2) / I$ と容量 Q_A から別の劣化判定式 (3) の係数 d, e, f, g を決定、それぞれ、 $d = 15.1, e = -11.3, f = 0.15, g = 0.208$ を得た。

【0118】このようにして作成した2つの劣化判定式に基づいて、回収したトリクル単三ニッケルカドミウム電池パック (3セル直列、公称容量600mAh) 10パックについて端子電圧測定を短時間放電前の所定の時間に実施した他は、実施例1と同様にして、容量推定と実際の容量測定を行った。

【0119】図9に結果を示す。すなわち、図9には、端子電圧 $Voc1$ 測定を短時間放電開始前に実施した時間と誤差範囲との関係を示した図である。図9から明らかに、測定した推定容量 Q と実測容量 Q_m とから得られた誤差は、短時間放電開始前の2秒以内の端子電圧測定を実施した場合、開始前2秒を越える時間で端子電圧を測定する場合に比べて、誤差が小さくなり高精度の容量推定を行えることが判った。

【0120】[実施例8] 実施例1に用いたのと同様の5つのトリクル単三ニッケルカドミウム電池パック (3セル直列) 新品を購入し、上記実施例1において求めた劣化判定基準式 (4) から劣化判定式を導いた。

【0121】すなわち、該電池パックを0.1CmA (60mA) の電流率で16時間充電し、1時間休止した後、0.2CmA (120mA) の電流率で3.0Vまで放電し、1時間休止を行う。この充放電を2回繰り返す、さらに、同じ条件で充電し休止した。次に1.0CmA (600mA) の電流率で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 $V2$ を測定し、該放電終了後2秒経過の時点の端子電圧 $Voc3$ を測定した。1時間の休止をおいた後、0.2CmA (120mA) の電流率で3.0Vまで放電を行い、この放電から容量 Q_A を求めた。内部抵抗 Z_A は $Z_A = (V2 - Voc1) / I$ から求めた。これらの値をもとに、劣化判定基準式 (4) の係数 $a = -1291$ と $b = 8490$ を補正して劣化判定式 (2) の係数 a', b' を以下の式で決定、以下に示す値を得た。

【0122】 $-174 = a (Q_A / Q_B)$

$1370 = Q_A - a (Q_A / Q_B) \ln (Z_A)$

その後、該電池パックを0.1CmA (60mA) の電流率で16時間充電し、1時間休止した。続いて、1.0CmA (600mA) の電流率で、10msecの間短時間放電し、該放電を終了する直前の端子電圧 $V2$ を測定し、該放電終了後2秒経過の時点の端子電圧 $Voc3$ を測定した。1時間の休止をおいた後、0.2CmA (120mA) の電流率で30分間放電し、2時間の休止をおいた。2時間休止が完了すると再び10msec短時間放電を実施、端子電圧 $Vx2$ を測定して短時間放電

を終了し、終了後2秒経過で端子電圧を測定し放電深度 x における開回路電圧 V_{ocx} とした。

【0123】放電中の端子電圧が3.0Vに到達するまで、この30分間放電、2時間休止、10msec短時間放電、端子電圧 V_{x2} 測定、端子電圧 V_{ocx} 測定の操作を繰り返した。これらの各放電深度 x における V_{ocx} と $Z_x = (V_{x2} - V_{ocx}) / I$ と容量 Q_A から別の劣化判定式(3)の係数 d, e, f, g を決定、それぞれ、 $d = 15.0, e = -11.4, f = 0.15, g = 0.210$ を得た。

【0124】このようにして作成した2つの劣化判定式を適用した、図3に示す、本発明になる容量および残量判定機能を具備した充放電試験装置を使用して、回収したトリクル単三ニッケルカドミウム電池パック(3セル直列、公称容量600mAh)10パックについて端子電圧測定を短時間放電終了後の所定時間経過で実施した他は、実施例1と同様にして、容量推定と実際の容量測定を行った。

【0125】図10に結果を示す。すなわち、図10は、端子電圧 V_{oc3} 測定を実施した短時間放電終了後所定時刻と誤差範囲との関係を示した図である。

【0126】図10から明らかなように、測定した推定容量 Q と実測容量 Q_m とから得られた誤差は、短時間放電終了後の2秒以内の端子電圧 V_{oc3} 測定を実施した場合、終了後2秒を越える時間で端子電圧 V_{oc3} を測定する場合に比べて、誤差が小さくなり高精度の容量推定を行えることが判った。

【0127】

【発明の効果】以上述べたように本発明によれば、短時間で満充電状態からの放電可能容量、および残量が比較的高精度で推定でき、無停電給電システムなどバックアップ電源の高信頼化と効率的なメンテナンス実施が期待できることになり大きな貢献を果たすことになる。

【図面の簡単な説明】

【図1】本発明になるニッケルカドミウム電池の容量を推定する判定式作成のための試験データであり、各放電深度(容量)と短時間放電に対する応答電圧 ΔV との関係を示したデータ図である。

【図2】本発明になるニッケルカドミウム電池の容量を推定する判定式作成のための試験データであり、開回路電圧 V と短時間放電に対する応答電圧 ΔV との関係を示したデータ図である。

【図3】本発明になるニッケルカドミウム電池の容量および残量を推定する機能を搭載した充放電試験装置の一例を示す構成概念図である。

【図4】本発明になるニッケルカドミウム電池の容量および残量推定機能を搭載した無停電給電システムの一部

を示す構成概念図である。

【図5】本発明の実施例1における残量推定に用いる容量と電圧の関係を示した基礎データの特性図である。

【図6】本発明の実施例1の結果を示した図であり、各放電状態における判定容量の実測容量に対する誤差を示した特性図である。

【図7】本発明の実施例1の結果を示した図であり、各放電状態における判定残量の実測残量に対する誤差を示した特性図である。

【図8】本発明の実施例2の結果を示した図であり、劣化判定使用の判断基準値 J と推定容量誤差との関係を示す特性図である。

【図9】本発明の実施例7の結果を示した図であり、端子電圧 V_{oc1} 測定時刻と推定容量誤差との関係を示した特性図である。

【図10】本発明の実施例8の結果を示した図であり、端子電圧 V_{oc3} 測定時刻と推定容量誤差との関係を示した特性図である。

【図11】本発明に係る電圧-容量曲線を求めるための放電、休止条件の一例を示す説明図である。

【図12】本発明に係る短時間放電の時間と容量推定誤差の一例を示す説明図である。

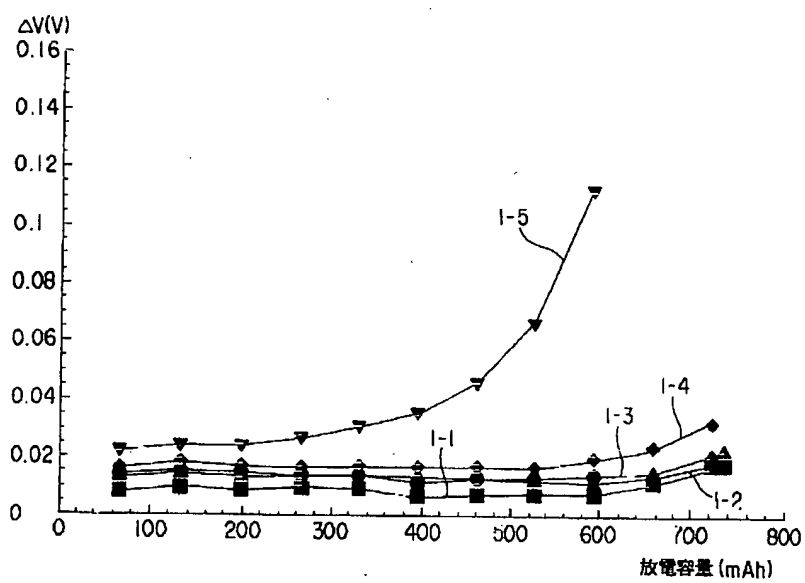
【図13】本発明に係る短時間放電の電流率と容量推定誤差の一例を示す説明図である。

【図14】本発明に係る短時間充電の電流率と容量推定誤差の一例を示す説明図である。

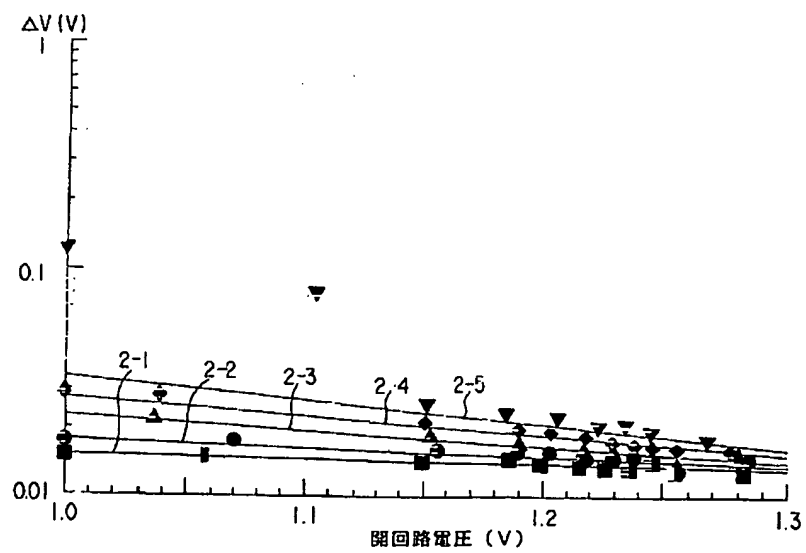
【符号の説明】

- 1 試験対象セル、あるいは組電池
- 2 充放電器
- 3 コンピュータ
- 4 定電流負荷装置
- 5 定電流定電圧電源
- 6 CPU
- 7 ROM
- 8 RAM
- 9 プリンタ
- 10 キーボード
- 11 表示器
- 12 充放電試験装置本体
- 13 交流、直流電源
- 14 電力変換装置
- 15 負荷装置
- 16 主変換回路
- 17 定電流制御回路
- 18 スイッチ
- S1, S2 充放電切り換えスイッチ

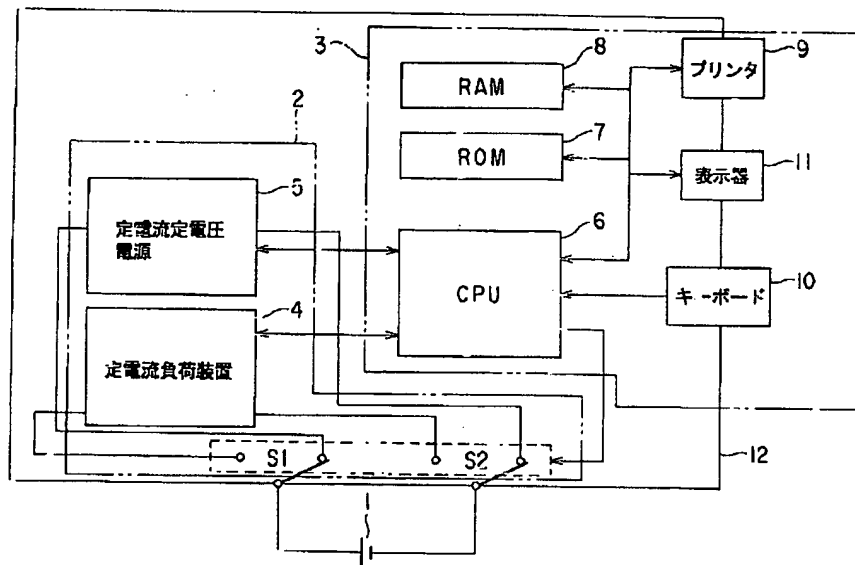
【図1】



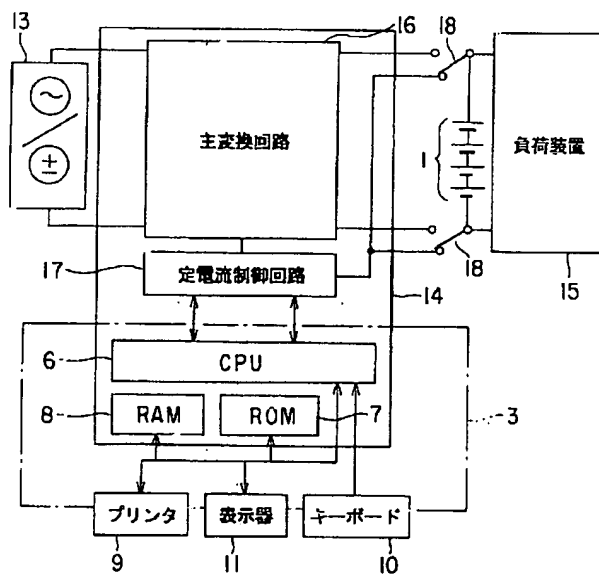
【図2】



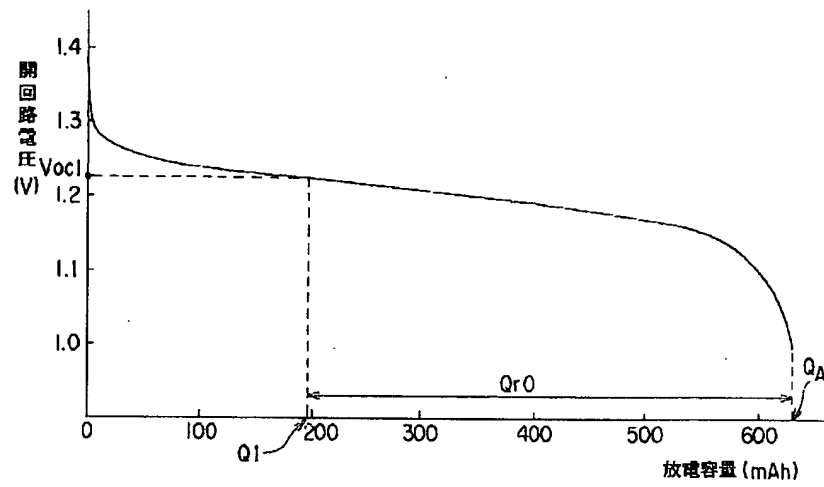
【図3】



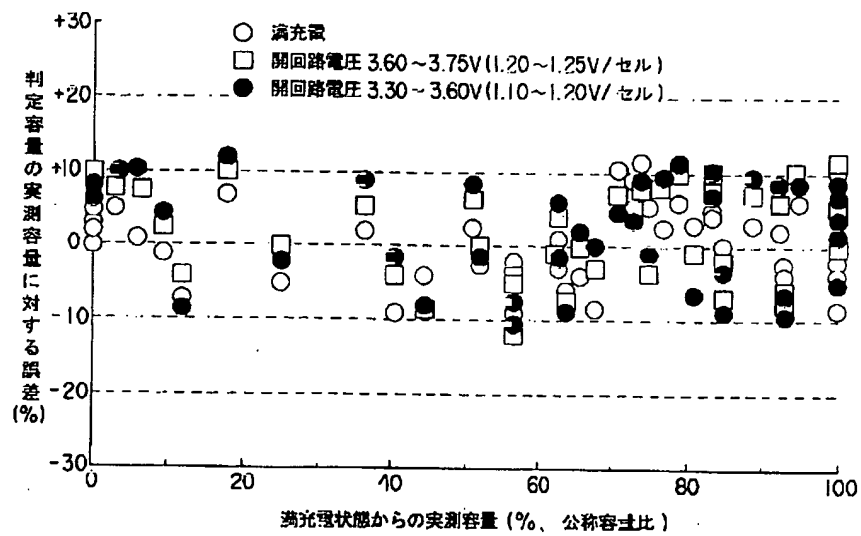
【図4】



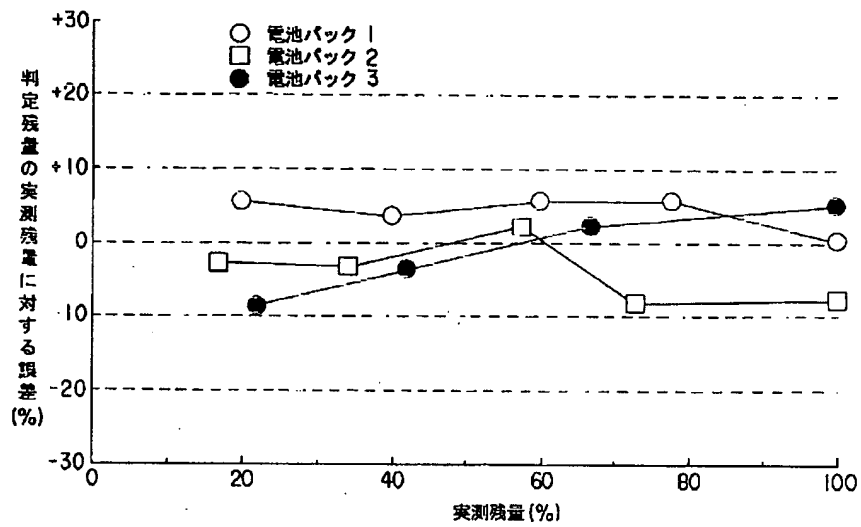
【図5】



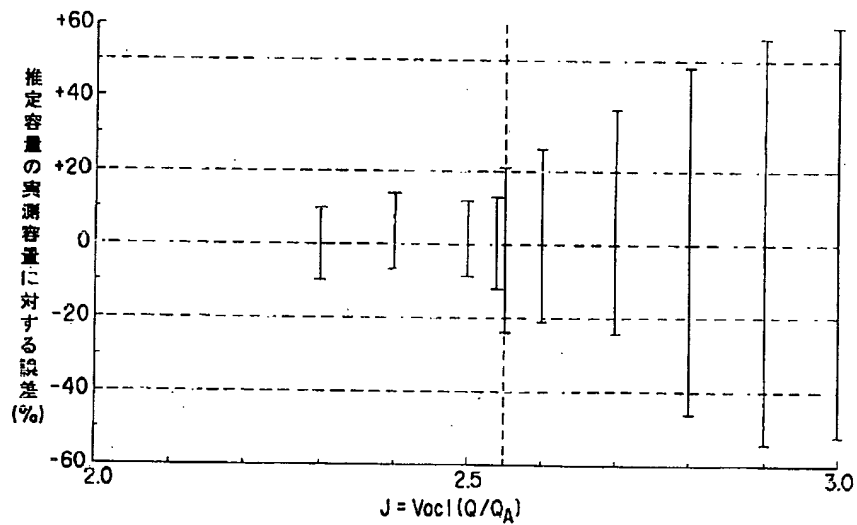
【図6】



【図7】



【図8】

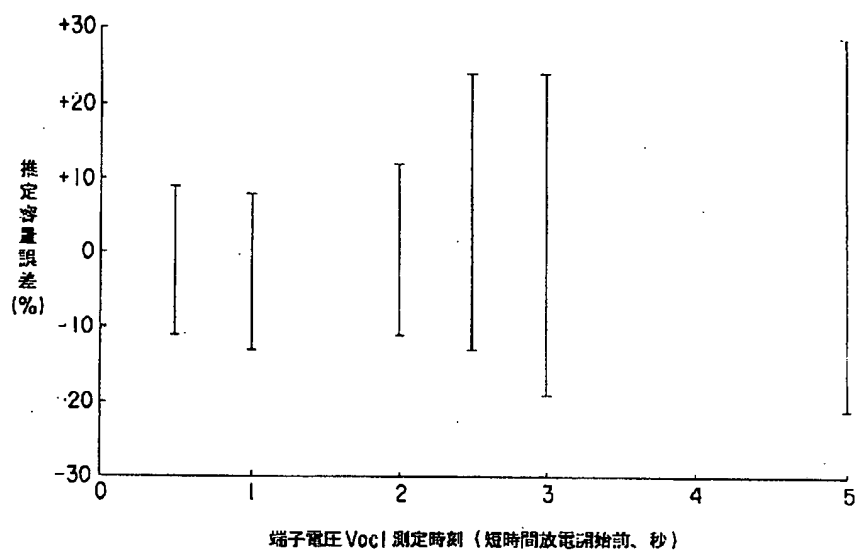


【図13】

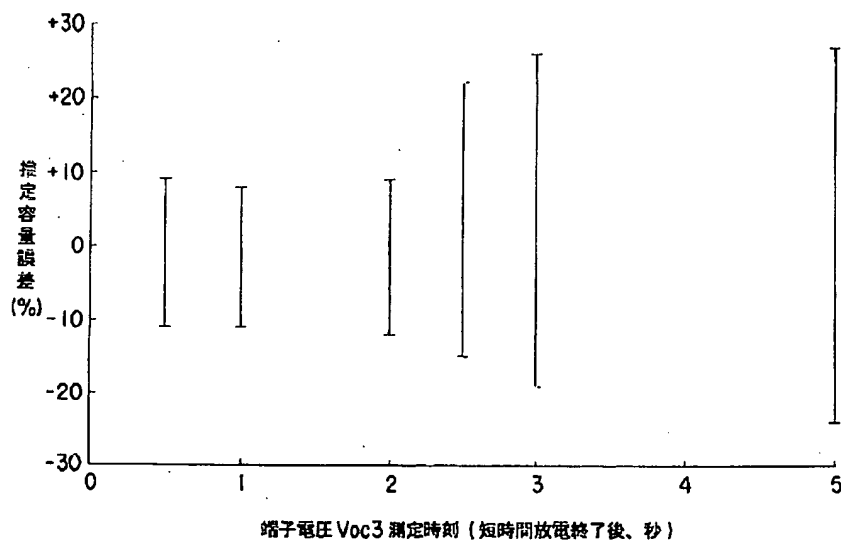
短時間放電の電流率と容量推定誤差

セル	16	17	18	19	20
放電率 (CmA)	0.1	0.4	0.5	0.75	1.0
式(2) 係数	a	-174	-175	-175	-174
	b	1371	1378	1372	1368
式(3) 係数	d	18.3	13.6	15.1	15.0
	e	-12.3	-14.6	-11.6	-11.4
	f	0.19	0.14	0.16	0.16
	g	0.249	0.232	0.210	0.205
最大誤差 (%, 絶対値)	41	28	14	11	12

【図9】



【図10】



【図11】

電圧-容量曲線を求めるための放電、休止条件

セル番号	放電		休止時間 (hr)	最大誤差 (絶対値、%)
	電流 (mA)	時間 (hr)		
1	60	0.5	2	9
2	120	0.5	2	12
3	300	0.5	2	26
4	120	0.17	2	7
5	120	0.33	2	7
6	120	0.15	2	16
7	120	1	2	29
8	120	0.5	0.5	38
9	120	0.5	0.15	27
10	120	0.5	1	13

【図12】

短時間放電の時間と容量推定誤差

セル		11	12	13	14	15
放電時間 t (msec)		10	100	800	1,000	1,200
式(2) 係数	a	-174	-175	-174	-175	-173
	b	1368	1395	1438	1474	1526
式(3) 係数	d	15.1	15.6	16.3	18.0	19.2
	e	-11.3	-12.4	-13.7	-14.4	-16.1
	f	0.15	0.15	0.16	0.16	0.19
	g	0.208	0.227	0.239	0.241	0.317
	最大誤差 (%, 絶対値)	12	9	13	14	29

【図14】

短時間充電の電流率と容量推定誤差

セル		21	22	23	24	25
放電率 (CmA)		0.04	0.05	0.06	0.1	0.2
式(2) 係数	a	-174	-173	-173	-175	-174
	b	1192	1225	1274	1380	1493
式(3) 係数	d	16.9	13.2	14.3	15.0	15.6
	e	-11.1	-13.5	-10.5	-11.2	-12.3
	f	0.14	0.16	0.11	0.15	0.16
	g	0.198	0.222	0.200	0.204	0.209
	最大誤差 (%, 絶対値)	49	14	12	11	11

フロントページの続き

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